Encyclopaedia of pests and natural enemies in field crops

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Introduction

Integrated pest management (IPM) requires the use of all information, tools and methods to keep pest populations below economically damaging levels and to minimise effects on human health and the environment.

This encyclopaedia covers a variety of pests associated with UK field crops. Use it to identify at-risk crops, understand life cycles, recognise symptoms/pests and determine management strategies. It also includes detailed information on the natural enemies (beneficial insects) that should be encouraged as part of IPM.

IPM: the three principal programme components

Prevent – suppress pest populations and the risk of economic damage. For example, use natural enemies, sow resistant varieties and manage rotations.

Detect – monitor pest/beneficial populations to determine when chemical control is justifiable. Includes the use of crop inspections, pest trapping, forecasts and thresholds.

Control – return pest populations to below damaging levels. Prioritise biological and physical methods over chemical interventions, where possible. Always manage environmental and resistance risks associated with the use of plant protection products.

Further information

To access the numerous tools, resources and additional information sources cited within this encyclopaedia, visit **ahdb.org.uk/pests**

Acknowledgements

AHDB is grateful for the contributions made by experts from ADAS, the Game and Wildlife Conservation Trust, Warwick Crop Centre, PGRO and BBRO in the production of the first edition of this encyclopaedia.

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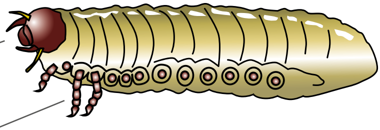
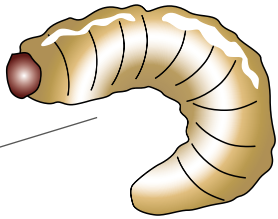
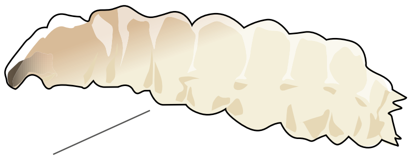


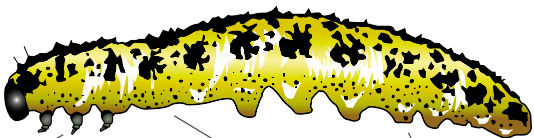
Weevil



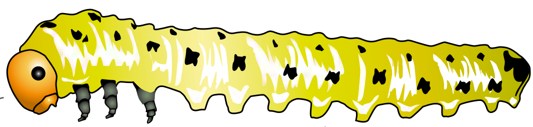
Fly



Moth/butterfly



Sawfly



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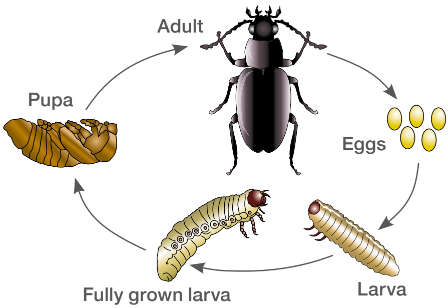
An introduction to beetles

Beetles (Coleoptera) occur in all types of habitats and are among the commonest insects on farmland. A few beetle species are crop pests, but most are harmless and some are important predators of crop pests.

Life cycle

As beetle larvae grow, they shed their outer skin in a series of moults. The developmental stage between each moult is called an 'instar'. When the larvae are fully grown, they undergo a final moult, which reveals pupae. This is a non-feeding stage, inside which the larval body is broken down and reassembled into the adult form.

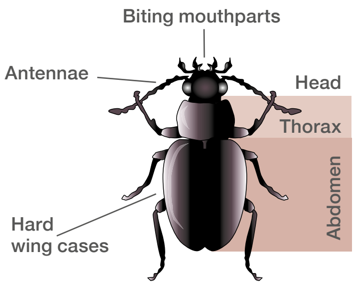


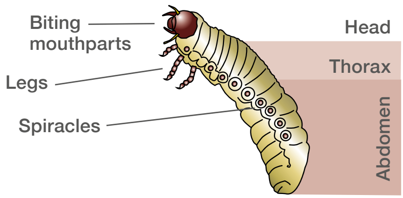
Defining features

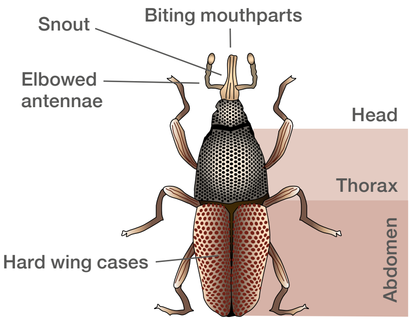
Adult beetles have a defined head and thorax and a distinct pair of hard wing cases covering the rest of their bodies. These meet in a line down the middle.

Beetle larvae have hardened, often dark, heads with biting mouthparts. They have three pairs of legs and spiracles (the openings of the respiratory system) along the sides of the body.

Weevils are a type of beetle.
The adults have a snout and angular antennae. The larvae do not have legs.







Bruchid beetle *Bruchus rufimanus*

Crops affected

Alliums	Carrots	Cereals	**Field beans**	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

In field beans, seeds damaged by bruchid beetle (also known as bean seed beetle or broad bean weevil) reduce the value of the crop for human consumption, export trade, or for seed.

In broad beans, the presence of damage or larvae make them unacceptable for processing and may lead to rejection of the crop.

Risk factors

- Common in the south of the UK, up to Yorkshire
- Risk is greater where fields have recently been affected
- Adults fly into crops when temperature reaches 15–20°C
- Winter and early sown spring crops are at highest risk

Life cycle, identification and symptoms

Adults are 3.5–4.5 mm long and black or dark brown with grey flecks on the wing cases which do not extend to cover the abdomen completely. The base of the antennae and front legs are a reddish colour.

The eggs are 0.5 mm long, cigar-shaped and white/yellowish.

Larvae are white with a light brown head and 3–4 mm long at maturity.

1. Adults overwinter in hedgerows or other dense, shrubby habitats.
2. Adults fly into flowering bean crops when the temperature reaches 15–20°C.
3. Adults feed on pollen for several weeks before laying eggs on pod, predominately at the base of the plant, once temperatures exceed 20°C.
4. Larvae bore into the seed and feed for several months, pupating within it as the seed matures and dries in the field or in storage. Adults emerge from the seed, leaving a circular hole.

There is one generation a year and this pest does not reproduce in stored produce.

Management

Non-chemical control

Later sowing of spring crops can reduce the risk of damage. Autumn crops are at increased risk as flowering and pod set are more likely to coincide with adult activity.

The parasitic wasp, *Triaspis luteipes*, attacks the beetle larvae. Small emergence holes in the seeds may be due to this natural enemy, which may impact crops destined for higher-quality markets. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Crops should be examined for adults during flowering. This can be done by tapping the flowering stems into the hand or a shallow tray.

Thresholds

Treatment should be applied when adults have been found in the crop, the temperature has reached 20°C on two consecutive days and beans have developed the first pods on the lowest trusses. Applying in the evening or at night will reduce the risk to foraging bees.

Insecticide resistance

None known.

Adult bruchid beetle with bean seeds

Bruchid beetle eggs

Bruchid beetle and damage

Cabbage seed weevil *Ceutorhynchus obstrictus*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Adult cabbage seed weevils lay their eggs within oilseed rape pods and the larvae feed on the developing seed.

Exit holes in the pods created by seed weevil larvae provide access for brassica pod midge adults to lay their eggs (see page 96). Yield losses from pod midge are potentially greater than direct losses from seed weevil.

Risk factors

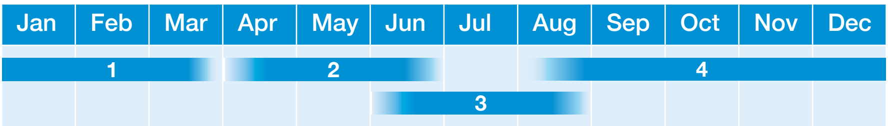
- Higher risk in the north of the UK

Life cycle, identification and symptoms

The adult is a small (2–3 mm) lead-grey to black weevil with a long snout.

Eggs are laid singly in young pods.

Larvae are plump, white, with a definite brown head capsule and no legs.



1. Adults overwinter in woods and hedgerows.
2. Adults migrate into crops during flowering and lay eggs in pods. A brown scar, usually resulting in a kink in the pod, indicates where the pod has been punctured for egg laying.
3. Larvae feed within the pod, consuming around 25% of the total seeds before burrowing out, leaving a neat circular hole. They fall to the soil to pupate.
4. Adults emerge in August. If brassica crops are present, they may continue to feed before overwintering.

Management

Non-chemical control

There are a number of parasitoid species that attack the egg, larval and adult stages of this pest. Encouraging their presence can help control. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Check the crop during flowering for the presence of the weevil. They are readily visible on flowering racemes on sunny days.

Thresholds

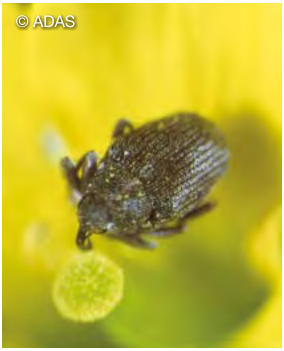
Northern UK: one every two plants.

Elsewhere: one per plant.

Insecticide resistance

None known.

Cabbage seed weevil



Cabbage seed weevil on oilseed rape flower

Cabbage seed weevil larva on oilseed rape

Cabbage stem flea beetle *Psylliodes chrysocephala*

Crops affected

Alliums	Carrots	Cereals	Field beans	**Lettuce**
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Cabbage stem flea beetle is a major pest of oilseed rape.

Large numbers of adults feeding in the autumn can kill emerging plants, occasionally resulting in total crop failure. Larval feeding in the stems and petioles reduces vigour and can cause severe damage, which may lead to stunting or plant death.

Larvae may feed within the stems of vegetable brassicas, such as spring cabbage and kale, during autumn and winter, but it is an incidental pest. This pest is of increasing importance in baby leaf salad crops, where adult feeding damage can make the crop unmarketable.

Risk factors

- Air temperatures above 16°C favour adult migration
- Mild autumn and winter weather favours prolonged egg laying and early hatch of larvae, coinciding with smaller, more vulnerable plants
- Crops drilled into dry and cloddy seedbeds can be slower to emerge and are more vulnerable to adult damage

Life cycle, identification and symptoms

Adults are 3–5 mm long, metallic blue-black or light brown. They have long antennae, large hind legs and jump when disturbed.

Larvae are white, with very small dark spots on the back, a black head and tail and three pairs of dark legs. They can reach 6 mm in length when mature.

1. Adults emerge and feed on foliage.
2. Adults ‘rest’ in moist, sheltered places.
3. Adults migrate into crops to mate and feed on foliage, causing characteristic shot-holing of the leaves.
4. Adults lay eggs and feed on leaves until temperatures drop.

5. Eggs hatch and larvae feed if temperatures are 3°C or warmer.
6. Larvae feed on main stem behind the growing point. Infested plants lose vigour, becoming stunted, and will die if the infestation is severe.
7. Larvae drop to the soil and pupate.

Management

Non-chemical control

Early sowing into good soil conditions can help the crop grow away from damage. Later sowing can reduce the time for egg laying to occur and reduce larval pressure but may lead to yield penalties.

High seed rates do not reduce damage but can lead to increased larval numbers per unit area.

Volunteer oilseed rape in neighbouring fields can attract migrating adults and act as a trap crop.

Defoliation of the crop has been trialled as a method of controlling larvae. This method can have yield penalties and should be done as early as possible (Dec–Jan) but may reduce pest populations in future years.

Carabid beetles (*Trechus quadristriatus*) feed on cabbage stem flea beetle eggs and young larvae before they enter oilseed rape plants. The parasitoids *Tersilochus microgaster* and *Microctonus melanopus* parasitise the larval and adult stages respectively. All parasitoids may be vulnerable to pyrethroid insecticides. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Two entomopathogenic fungi (*Beauveria bassiana* and *Metarhizium anisopliae*) can infect cabbage stem flea beetles, but their impact on the field populations is unknown.

Cabbage stem flea beetle creating shot-holing symptoms

Adult cabbage stem flea beetle damage on oilseed rape

Adult cabbage stem flea beetle larva

Monitoring

For early warning signs, check for large numbers of cabbage stem flea beetle in previously harvested seed and shot-holing on volunteer oilseed rape. Monitor for pest damage as soon as crops begin to emerge. The amount of leaf area eaten can determine the need for treatment.

To predict larval populations, set two yellow water traps on the headland and two in the field along a wheeling during beetle migration (around early September). Fill them with water and a drop of detergent. Empty and reset the traps weekly, recording the number of cabbage stem flea beetles and adding it to the previous total for that trap. Remove the traps at the end of October. Calculate the average number of beetles/trap for the whole monitoring period.

Plant dissection involves taking a random sample of 25 plants in late October/early November. Samples are best dissected by an accredited laboratory.

Thresholds

Assessing the need to spray adults in oilseed rape:

- >25% leaf area eaten at the cotyledon–2-leaf stage
- >50% leaf area eaten at the 3–4-leaf stage
- The crop is growing more slowly than it is being consumed

Assessing the need to spray larvae in oilseed rape:

- >100 beetles/trap (average) caught over the monitoring period
- >5 larvae/plant, when dissected
- >50% of petioles damaged

Insecticide resistance

Resistance to pyrethroids is widespread in the UK.

Cabbage stem flea beetle on an oilseed rape leaf

Cabbage stem weevil *Ceutorhynchus pallidactylus*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Cabbage stem weevil affects oilseed rape and vegetable brassicas. Although it rarely causes economic damage in oilseed rape, cosmetic damage can be a problem for high-value brassica crops.

Importance

Cabbage stem weevil is frequently recorded in oilseed rape, occasionally causing economic damage. Larval feeding and tunnelling can result in premature leaf drop and discolouration to the stem. Exit holes made by the larvae can increase the risk of disease. Some stunting and loss of vigour can occur, especially in spring rape.

It can infest vegetable brassicas and may cause cosmetic damage to high-value crops, such as cauliflower. Damage can be caused by feeding adults as well as larvae. It is currently an occasional and minor pest of vegetable brassicas.

Risk factors

- Spring crops in southern counties
- Minor pest in winter crops

Life cycle, identification and symptoms

Adults are 3 mm long with a long snout, reddish legs and antennae. They are dark grey with a fine layer of yellow-white scales and a white spot in the middle of the back.

Larvae are creamy white with a brown head and no legs and grow to 4–5 mm long. At maturity, they bore an exit hole in the lower stem and drop to the soil to pupate.

1. Adults overwinter in sheltered locations.
2. Adults migrate into the crop, laying eggs in clusters under the leaf surface. Blisters near the main vein on lower leaves in early summer indicate where eggs have been laid.
3. Eggs hatch and larvae tunnel into the stem to feed. At maturity, they drop to the soil to pupate, leaving visible exit holes in the stem.
4. Adults emerge and feed for a short time.

Management

Non-chemical control

Early drilling can minimise the risk of damage, as established plants show a greater tolerance to the feeding.

Natural enemies include spiders, ground beetles, rove beetles, predatory flies, and parasitoids of egg, larval and adult stages. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Check crops in late spring/early summer for migrating adults. It is possible to trap adults in yellow water traps to indicate when females are laying eggs.

Thresholds

None established.

Insecticide resistance

None known.

Cabbage stem weevil

Damage by cabbage stem weevil

Pea and bean weevil Sitona lineatus

Crops affected

Alliums	Carrots	Cereals	**Field beans**	Lettuce
Oilseeds	**Peas**	Potatoes	Sugar beet	Vegetable brassicas

Importance

Pea and bean weevil (also called pea leaf weevil) can cause yield reductions in field and broad beans, and in combining, vining and fresh market peas. Adult feeding does not normally cause significant damage, but larval feeding within the root nodules can affect yield. The larvae are difficult to target and pressure from this pest has increased in recent years.

Adults can transmit the *Broad bean stain virus* (BBSV) and the *Broad bean true mosaic virus* (BBTMV), which cause leaf malformation with light and dark green mottling and yellowish blotching. This can affect product quality and result in large yield reductions, if the infection occurs early.

Risk factors

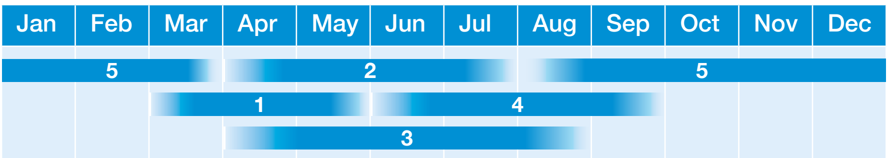
- Increased risk to crops near to leguminous plants or grassy margins in fields previously cropped with peas or beans
- Newly emerged crops are at risk from adult feeding during migration, which often occurs when the maximum air temperature exceeds 15°C
- Spring-sown and backward crops are at highest risk of damage
- Nitrogen-poor soil or drought conditions increase risk of larval feeding damage

Life cycle, identification and symptoms

Adults are 4–5 mm long and light brown, with faint creamy yellow stripes along the length of the wing cases. They have a short ‘snout’ with the ‘elbowed’ antennae typical of weevils.

Eggs are oval and white when laid but darken as they mature.

Hatching larvae are legless and white with a brown head, reaching 4–5 mm in length when mature.



1. Adults migrate into crops when temperatures rise above 15°C for short periods. Adult feeding damage is evident as notching around the leaf margins and is usually first noticeable at field edges.

2. Eggs are laid on, or around, crops and are washed into soil at the crop base.
3. Eggs hatch and larvae enter root nodules to feed.
4. Larvae move out of the root nodules and pupate about 5 cm below the soil surface.
5. Adults emerge and overwinter in grasses and leguminous crops, such as clover and lucerne.

Pea and bean weevil feeding

Management

Non-chemical control

Avoid cropping in areas that have previously had large pea and bean weevil populations. Natural enemies include spiders, ground beetles, rove beetles, predatory flies and parasitoids. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

A monitoring system that detects migrating adult weevils in early spring has been developed by Rothamsted Research with PGRO and ADAS.

Five cone traps containing pheromone lures should be sited on a single grassy verge or headland of a field that had contained peas or beans the previous year. The traps should be placed by mid-February and monitored three times a week until a threshold catch is reached, or until the latest-sown crops have emerged (whichever is the sooner). This system can identify periods of peak weevil activity and inform treatment requirement and timing, as well as optimum drilling time (i.e. to avoid periods of serious damage).

Pea and bean weevil damage

Thresholds

Spring-sown peas and spring field beans:
An average of 30 or more weevils per trap on any one recording day.

The crop may be at risk if the threshold is reached when the crop has just emerged or is due to emerge in the next ten days.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

Pollen beetle *Meligethes* spp.

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

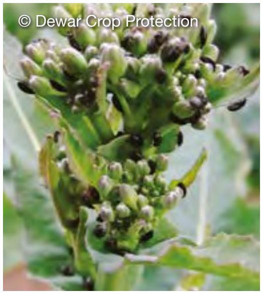
Importance

In oilseed rape, the damage-susceptible stage is green-to-yellow bud. Adult and larval feeding can lead to bud abortion and reduced pod set. Damage rarely results in reduced yields for winter crops, but spring crops can be more vulnerable as the susceptible stage often coincides with beetle migration. Oilseed rape usually compensates for early damage by producing more seeds on lower racemes.

Adults are occasional pests of cauliflower and broccoli, feeding on the curds or florets in midsummer when new adults emerge from oilseed rape crops and move into other areas to feed.

Risk factors

- Risk of damage increases when adult migration coincides with the green-to-yellow-bud growth stage
- Spring crops, backward crops and those suffering from pigeon damage are at greater risk
- In vegetable brassicas, the risk of infestation is higher, if crops are close to fields of oilseed rape

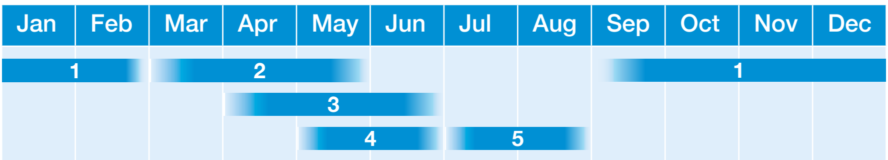


Pollen beetles on oilseed rape

Life cycle, identification and symptoms

The adults are around 2.5 mm long, metallic greenish-black and have clubbed antennae.

The larvae are creamy white, with a black head, three pairs of legs and dark brown spots and short bristles along the back. They grow to 3–4 mm long.



1. Adults overwinter in sheltered spots.
2. Adults migrate into oilseed rape crops when temperatures exceed 15°C. They feed on pollen inside buds or in open flowers.
3. Females bite slits in the base of oilseed rape buds and lay their eggs inside.
4. Larvae feed on pollen before pupating.
5. Adults emerge and feed on a variety of plants.

Once the crop starts flowering, the beetles move to the open flowers, becoming pollinators rather than pests.

Management

Non-chemical control

Pollen beetle larvae are attacked by parasitic wasps during flowering. Insecticides can considerably decrease parasitism. Parasitism can be enhanced by planting oilseed rape crops close to where the crop was grown in the previous year and through trap cropping with turnip rape, which can often reduce populations of pollen beetle to below threshold.

Minimum tillage following oilseed rape will also enhance survival of parasitoids.

Other natural enemies include spiders, ground beetles and rove beetles. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

The AHDB Pest Bulletin website forecasts pollen beetle migration into vegetable brassica crops, helping growers to target crop walking.

In oilseed rape, estimate plant population per m^2 by counting the number of plants within a square foot and multiplying by 11. This is easiest at the 5–6-leaf stage. Use the plant population to determine the threshold. Count adults on the plant during the green-bud stage.

Pollen beetle damage to cauliflower

Thresholds

Oilseed rape

Thresholds are based on the maximum number of buds each beetle can destroy and the number of excess flowers produced. Low plant populations tend to produce more branches and more flowers.

Threshold number of beetles per plant at the green-to-yellow-bud stage:

- If there are fewer than 30 plants/m^2: 25
- If there are 30–50 plants/m^2: 18
- If there are 50–70 plants/m^2: 11
- If there are more than 70 plants/m^2: 7

Vegetable brassicas

None established.

Blind stalks on oilseed rape due to pollen beetle damage

Insecticide resistance

Resistance to pyrethroids is widespread in the UK.

Rape winter stem weevil *Ceutorhynchus picitarsis*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Rape winter stem weevil is an occasional pest of oilseed rape. It first came to attention in 1982, following severe infestations in eastern and southeastern England (especially Lincolnshire and Cambridgeshire). The pest has since spread to other areas. Most damage is caused by the larvae feeding within stems; adult feeding is not considered important.

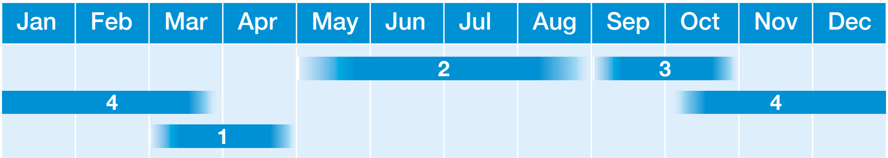
Risk factors

- Risk increases risk near wooded areas

Life cycle, identification and symptoms

Adult beetles are 2.5–4.0 mm long, metallic black, with elongated snouts, elbowed antennae and reddish-brown leg tips.

Hatching larvae are white, plump and legless, with an orange-brown head. They can reach 5 mm in length.



1. Adults invade autumn-sown oilseed rape crops and feed on leaves.
2. Eggs are laid in punctures and crevices in the leaf stalk and plant crown. Egg laying continues throughout winter in mild conditions. Hatching larvae bore into the stem and down to the crown of the plant to feed.
3. Mature larvae descend to the soil to pupate.
4. Adults emerge from the soil and disperse to woods and hedges, where they enter a resting phase.

The effect of larval feeding can vary widely, depending on the number of eggs laid on the plant. The larvae can destroy the terminal shoot. This either kills the plant or results in the development of secondary shoots. Surviving plants may be stunted with a rosette-like appearance. Attacked crops tend to be irregular and patchy, with uneven flowering and ripening.

Management

Non-chemical control

Natural enemies include spiders, ground beetles, rove beetles and several parasitoid species. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Monitoring can be challenging because adults and larvae are difficult to find. Inspect the crop for young larvae from late October, especially in fields with a history of attack by this pest.

Thresholds

None established.

Insecticide resistance

None known in the UK.

Adult rape winter stem weevil

Rape winter stem weevil damage

Rape winter stem weevil larva

Wireworms *Agriotes* spp.

Crops affected

Alliums	**Carrots**	**Cereals**	**Field beans**	**Lettuce**
Oilseeds	**Peas**	**Potatoes**	**Sugar beet**	Vegetable brassicas

Importance

Wireworms are the soil-inhabiting larvae of click beetles (Elateridae). They are common in grassland, especially old permanent pastures, but attack a variety of crops. Wireworms feed in ploughed-down turf for about 6 months, before moving to the surface to damage the next two crops.

Wireworms feeding on potatoes can cause significant reductions in tuber marketability, even at low populations.

The pest can affect all winter cereal or winter cereal/grass ley rotations. It has become more serious since the withdrawal of organochlorine insecticides. Heavy infestations can cause yield losses of up to 0.6 t/ha.

Leeks are also prone to damage and entire crops can be lost by heavy infestations.

The larvae burrow into the roots of crops, such as carrot, and damage vegetable seedlings.

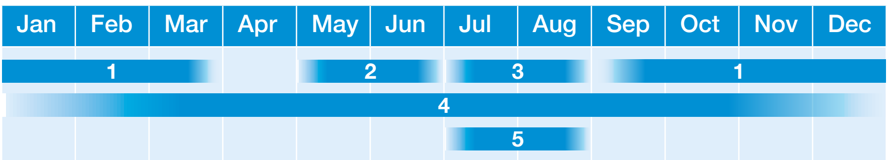
Risk factors

A pre-planting assessment of wireworm risk is essential.

- Crops sown within 2 years of ploughing out permanent pasture are at highest risk
- Rotations dominated by winter cropping, particularly with grass weeds or grassy margins, are at increased risk
- South-facing, sloping fields, heavy alluvial soils and minimum tillage cereal crops are associated with higher risk
- Late-lifted potatoes are at greater risk

Life cycle, identification and symptoms

There are three key species: *Agriotes lineatus, A. obscurus* and *A. sputator*. The larvae of the three species are indistinguishable by conventional means.



1. Adults overwinter below soil surface.
2. Females lay eggs just below the soil surface.
3. Eggs hatch.
4. Larvae (wireworms) feed for 4–5 years.
5. Larvae pupate.

Adult beetles have a dark brown-to-black elongated body (8–15 mm long and 2–3 mm wide), which is covered in fine whitish-grey hairs. The adults live for about 1 year.

Newly hatched wireworms are transparent, white and 1.3 mm long. They grow to up to 25 mm long and turn shiny golden brown. They have a cylindrical body, tough skin, three pairs of legs at the head end and two dark spots at the tail. The head is dark brown, with powerful biting mouthparts.

Larvae leave ragged holes at the base of the stem in cereals, sugar beet and leeks, moving along rows to attack further shoots. Damage to potato tubers and carrots is visible as small, round holes on the surface leading to narrow tunnels.

Injury on young sugar beet seedlings appears as small wounds that rapidly blacken on the stem below soil level, usually causing the seedling to wilt and die.

Management

Non-chemical control

The consolidation of seedbeds helps to restrict pest movement. Control of grass weeds can reduce the availability of food sources. Rolling a thin crop may also encourage tillering. In arable rotations, plough-based cultivation may help to reduce populations. A spring rotation in cereal crops can also be beneficial.

For potatoes, avoid wireworm-infested fields and consider lifting the crop early, especially if damage is expected.

The main natural enemies are fungi and parasitic wasps. Larval stages are attacked by ground beetles and adults are eaten by birds.

Wireworm

Wireworms

Wireworm in potatoes

Use the SAFE approach to encourage natural enemies – see pages 185–186.

No commercial biological control agents are currently available for wireworm control in the UK, although some strains of the insect-pathogenic fungi *Metarhizium anisopliae* and *Metarhizium brunneum* have shown encouraging results under experimental conditions.

The use of cruciferous plants as green cover crops or de-fatted mustard meals as soil amendments has been shown to reduce wireworm populations in Italy.

Monitoring

Bait and pheromone traps can be used to determine the presence or absence of wireworms and click beetles, respectively. However, traps do not provide a reliable indication of the level of infestation. Soil samples can be used to assess population size and provide a reasonably good estimation of subsequent damage in potato crops. However, accurate estimations are difficult because populations can be patchy. Additionally, wireworm populations can cause significant damage, even at the lower limit of detection in potato crops (60,000 per hectare).

For cereals, examining field soil cores for larger wireworms, or in the laboratory for smaller ones, is costly and rarely justified.

Thresholds

Potatoes

A single wireworm in 20 soil cores of 10 cm in diameter (equivalent to approximately 60,000 per hectare) can represent a significant risk in the following crop.

Cereals

If wireworms exceed the threshold of 750,000 per hectare (as determined by soil extraction), use a seed treatment. Even where a seed treatment is used, damage can still occur under high pest pressure (1.25 million per hectare).

Wireworms and click beetle

Click beetle pheromone trap

Adult click beetle

Other crops

None established.

Insecticide resistance

None known.

Wireworm damage in onion

Wireworm damage in onion

Wireworm damage in onion

Wireworm damage in sugar beet (left: treated; right: untreated)

Minor and/or emerging pests

Cereal ground beetle (*Zabrus tenebrioides*)

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

The cereal ground beetle attacks crops in England, from Oxfordshire and Cambridgeshire southwards.

Larvae burrow into soil, pulling down and eating shoots from October to May. Adult beetles feed on cereal ears before harvest and on split grain and stubble regrowth.

Damage is worst in all-cereal rotations and with minimal cultivations. A non-cereal break crop or early ploughing will provide good control.

Cereal ground beetle

Cereal leaf beetle (*Oulema melanopus*)

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

The cereal leaf beetle is commonly seen in cereal crops, especially oats, across the country from mid-summer. Adults are 4–5 mm long, with a red thorax and blue-green metallic wing cases. The larva covers itself with a mixture of mucus and excreta. It can attach itself easily to clothing during crop walking.

Adults and larvae eat long, thin strips from the leaves, leaving the lower epidermis intact.

They are very rarely of economic importance and predation usually keeps the population in check.

Cereal leaf beetle larva

Chafer grubs (*Melolontha melolontha*)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	**Sugar beet**	Vegetable brassicas

Importance

The most common species of chafer in the UK is the cockchafer or May bug, although garden chafers and Welsh chafers are also common. Adult beetles are large (2.5 cm long) with a reddish-brown body and black head. In May, they fly to feed in woodlands and during the summer they lay eggs in the soil in grassland or cereals. Larvae develop over the next 3 years and are most damaging in their second or third years. Attacks are localised and sporadic. Control is not usually economically justified.

Chafer grub

Adult garden chafer

Colorado beetle (*Leptinotarsa decemlineata*)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	Sugar beet	Vegetable brassicas

Importance

The Colorado beetle, also known as the Colorado potato beetle, is a serious pest of potatoes originating from North America. The pest gained a foothold in France in 1922. Since then, it has since spread to most European countries. Although not established in the UK, it is a notifiable quarantine pest. A single fertilised beetle can establish a breeding colony. If the pest is found or suspected, contact your local Defra Plant Health and Seeds Inspector.

Adult Colorado beetle

Other flea beetles

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	**Vegetable brassicas**

Importance

Some flea beetles, including Wessex, striped and turnip flea beetles, cause occasional crop damage. *Phyllotreta* species can be very damaging pests of seedling crucifers such as swede and rocket.

The Wessex flea beetle is of increasing importance in southern England and is most likely to severely check earlier sown, slow-growing oilseed rape.

The striped and turnip flea beetles are principally pests of spring brassicas, of which later-sown crops are most susceptible; however, any crop may be at risk if growth is checked by sunny, dry weather.

Adult beet, or mangold flea beetles, can cause serious damage to the upper or lower surface of cotyledons, leaves and petioles of sugar beet. They overwinter in sheltered spots (field margins or hedges) and emerge in spring. Eggs are laid in late spring and larvae feed on roots before pupating. However, most damage is caused by adults feeding in the spring, especially when the pest is present in large numbers and plant growth is slow.

In recent years, flax flea beetle has emerged as a pest of linseed. It can damage emerging crops, especially when growing conditions are poor.

All of these beetles are smaller than the cabbage stem flea beetle (see page 20).

Striped flea beetle

Flea beetle damage to sugar beet

Pygmy beetle (*Atomaria linearis*)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

Importance

The pygmy beetle, or pygmy mangold beetle, is a small, elongate beetle of 2 mm in length, which can damage sugar beet seedlings. Damage after the six true leaf stage is rarely of economic significance.

The beetle bites on the root and hypocotyl causing small black pits, which may allow invasion by parasitic fungi. Severe damage can destroy the vascular tissue, causing the seedling to collapse. Cotyledons and leaves may also be eaten, leaving irregular-shaped holes.

The adults overwinter in the soil and survive on beet crowns left after harvest. In spring, they move to the soil surface and fly on warm, still days (from May onwards) to colonise new beet fields. In dry weather, the beetles move deep into the soil. In humid weather, they move to the soil surface and feed on the hypocotyl and leaves.

Eggs are laid in late spring and summer. The larvae feed on roots of well-grown plants, causing little damage.

Seedlings are most sensitive to damage from adults in fields in which beet is grown in close rotation, or where crops are infested early from adjacent fields with beet the previous year. Rotation is usually the most effective control.

Pygmy beetle

Wheat shoot beetle (*Helophorus nubilus*)

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

The wheat shoot beetle, sometimes known as the wheat mud beetle, is an occasional pest of winter cereals following a grass rotation.

The larvae feed at the base of the shoot, causing the plant or central leaves to yellow and die.

Damage is usually seen from January to March, but can be avoided by leaving an interval between ploughing grass and drilling the crop – 1 month should be sufficient under most conditions.

Wheat shoot beetle

Pests: Bugs and thrips

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44 **Bird cherry–oat aphid (*Rhopalosiphum padi*)**

46 **Black bean aphid (*Aphis fabae*)**

48 **Buckthorn–potato aphid (*Aphis nasturtii*)**

50 **Cabbage whitefly (*Aleyrodes proletella*)**

52 **Currant–lettuce aphid (*Nasonovia ribisnigri*)**

54 **Field thrips (*Thrips angusticeps*)**

56 **Grain aphid (*Sitobion avenae*)**

60 **Lettuce root aphid (*Pemphigus bursarius*)**

62 **(Mealy) cabbage aphid (*Brevicoryne brassicae*)**

64 **Onion thrips (*Thrips tabaci*)**

66 **Pea aphid (*Acyrthosiphon pisum*)**

70 **Pea thrips (*Kakothrips pisivorus*)**

72 **Peach–potato aphid (*Myzus persicae*)**

76 **Potato aphid (*Macrosiphum euphorbiae*)**

78 **Rose–grain aphid (*Metopolophium dirhodum*)**

80 **Tarnished plant bug (*Lygus rugulipennis*)**

82 **Willow–carrot aphid (*Cavariella aegopodii*)**

84 **Minor and/or emerging pests**

84 Potato leafhoppers

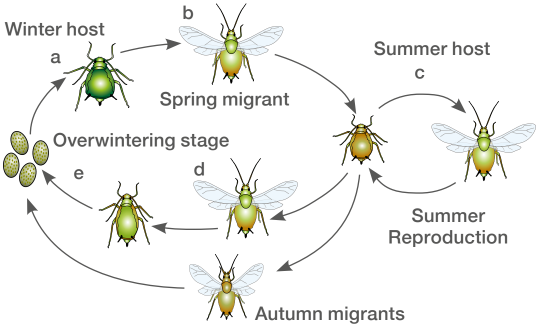
85 Other thrips (*Caliothrips fasciatus*)

An introduction to bugs and thrips

Bugs

(Hemiptera) include true bugs (Heteroptera), aphids and whiteflies (Sternorrhyncha) and hoppers (Auchenorrhyncha). Many species are plant-feeding pests, some spread plant viruses and others are natural enemies (see page 193).

Life cycle

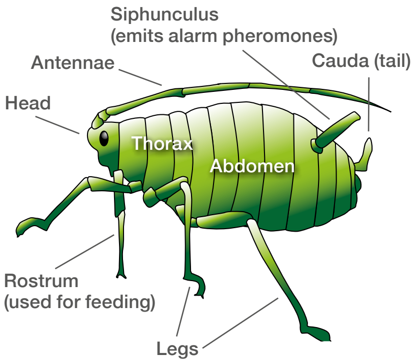


Bugs often have complex life cycles, especially aphid species. Even bugs associated with relatively simple life cycles (for example, whiteflies and hoppers) share the same basic features.

Most agronomically important aphid species have separate winter and summer hosts. In spring, when conditions are suitable, new individuals emerge and develop into fundatrices (a). These reproduce asexually. Their offspring develop wings (b) and migrate. Many more asexual generations are produced on the summer hosts (c).

In the autumn, winged males and females are produced (d), which migrate back to the winter host. These then mate and overwinter, either as eggs (e) or active stages. Some aphid species are able to reproduce asexually all year round.

Defining features



Bugs are characterised by their sucking mouthparts, which comprise a piercing, segmented rostrum and compact, often flattened bodies. The front pair of wings is usually leathery and the back pair is usually membranous.

Immature aphid and plant bug stages (nymphs) resemble smaller versions of the wingless adults, while whitefly nymphs resemble oval, flattened scales. Nymphs progress through a number of instar stages before becoming adults.

Thrips

Thrips (Thysanoptera), commonly known as thunderflies, are not actually flies and are more closely related to bugs. They are tiny, slender insects with fringed wings. Plant-feeding thrips puncture the plant tissue and suck out the contents; some species are vectors for plant viruses.

Bird cherry–oat aphid *Rhopalosiphum padi*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

The bird cherry–oat aphid is an important vector of *Barley yellow dwarf virus* (*BYDV*), particularly in the southwest of England, where many aphids remain in the asexual form and overwinter in winter cereals. Even very small populations, which may go unnoticed, can cause economic damage.

Rarely, direct feeding by this pest can also damage cereal crops. It can also infest sweetcorn.

Risk factors

- Early drilling increases risk
- Mild autumn and winter weather increases risk
- Winter, rather than spring, crops are at higher risk
- Crops are most at risk if infected prior to growth stage 31
- Plant stress increases the risk of yield losses to *BYDV*

Life cycle, identification and symptoms

The wingless adult aphids are 1–2 mm long, broadly oval-shaped and green-to-dusky brown, with rust-red patches at the rear. Winged adults are a similar size, with a pale-to-dark green abdomen and similar rust-red patches.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1		2	3		4			5		1

1. Eggs overwinter on bird cherry trees (*Prunus padus*).
2. Eggs hatch.
3. Winged forms migrate to cereals and grasses.
4. Multiple generations occur, infesting lower leaves and stems first.
5. Winged forms migrate back to bird cherry trees. In mild conditions, asexual forms can remain and feed in cereal crops.

Typically, initial symptoms of *BYDV* infection show on plants scattered throughout the crop with bright yellow upper leaves. Later, as infection spreads, larger areas of the crop become infected, appearing as patches of bright yellow and severely stunted plants.

Management

Non-chemical control

Ground beetles, spiders and parasitoids are natural enemies that are active in autumn and winter, although parasitoids may only be active in mild winter weather. Grass banks and field margins provide habitats for these natural enemies, but can also harbour infective aphids. Use the SAFE approach to encourage natural enemies – see pages 185–186.

If high levels of aphid-infested grasses, especially annual meadow grass, are present in the stubble, a desiccant herbicide or ploughing may be beneficial to remove this green bridge. However, the risk of infestation by winged aphids in the autumn is lower following minimum tillage – more so if the straw is left, compared with ploughing. Delaying sowing so that crops emerge after the end of the aphid migration (usually early November) will also reduce *BYDV* risk, but this is not always practical.

Some *BYDV*-tolerant varieties are available and described in the AHDB Recommended Lists for cereals and oilseeds.

Bird cherry–oat aphid

Symptoms of *Barley yellow dwarf virus*

Monitoring

A few bird cherry–oat aphids can spread economically significant levels of *BYDV*. Inspect crops for wingless aphids, which initially colonise the lower parts of the plant. Yellow sticky traps and water traps placed on the soil surface near headlands can also be used for aphid monitoring.

Access aphid monitoring tools via:
ahdb.org.uk/pests

Thresholds

Because there is insufficient information on the prevalence of virus-carrying aphids, assume aphids carry *BYDV*. Although no treatment thresholds exist, use the AHDB *BYDV* tool to time any necessary treatment.

Insecticide resistance

None known.

Black bean aphid *Aphis fabae*

Crops affected

Alliums	Carrots	Cereals	**Field beans**	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

Importance

The black bean aphid can cause significant damage to faba bean crops, especially through direct feeding. Honeydew produced during feeding also encourages chocolate spot (caused by *Botrytis* spp.), which can reduce yields. The aphid can also transmit viruses, such as *Bean leafroll virus* (*BLRV*), *Pea enation mosaic virus* (*PEMV*), *Bean yellow mosaic virus* (*BYMV*) and *Beet yellows virus* (*BYV*).

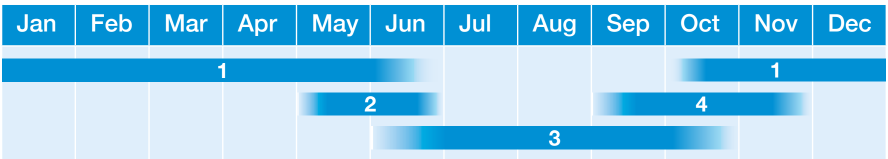
On spinach and sugar beet, populations can develop rapidly on the undersides of leaves, causing them to become chlorotic and crinkled.

Risk factors

- Spring crops, particularly late-sown crops, are at higher risk than winter crops
- Aphid colonies can grow rapidly in the summer, especially if conditions are warm and humid
- There is a tendency for serious infestations to occur in alternate years, so severe attacks can be expected in a year following little or no infestation

Life cycle, identification and symptoms

The wingless adults are 1.5–3 mm long, black or olive green, often with distinct waxy stripes. Winged adults are very dark, with faint black crossbars on the upper surface of the abdomen.



1. Eggs overwinter on spindle (*Euonymus europaeus*). In mild winters, active stages may overwinter on leguminous weeds or winter beans.
2. Winged forms migrate into a variety of summer crops.
3. Breeding continues throughout the summer, usually peaking in July/August. Colonies are often attended by ants and can become very large and dense, developing from the top of the plant downwards. In response to crowding, further winged forms are produced, which spread within the crop and to other crops.
4. Winged forms migrate back to spindle to lay eggs.

In beans, direct feeding can damage flowers, retard or prevent pod development and cause plants to lose vigour and wilt in dry conditions. Direct feeding damage on sugar beet is rarely worth controlling.

BLRV causes leaf yellowing, upward leaf-rolling and a decrease in pod numbers. Symptoms are often more obvious if aphids colonise before flowering.

PEMV in beans causes vein clearing and the formation of translucent spots on leaves. Upper leaves become pointed and crinkled and may contain necrotic spots. Symptoms of an advanced infection are the cessation of terminal growth, the disappearance of axillary buds and impairment of flower set.

Following *BYMV* infections, leaves become crinkled and occasionally pointed, the plant becomes stunted and vein clearing may occur. Symptoms can be mistaken for *PEMV*, but without the translucent spotting and streaking on the leaf surface.

Black bean aphids

Management

Non-chemical control

Natural enemies include parasitic wasps, ladybirds, hoverflies, lacewings and insect-pathogenic fungi. Although these may help control aphid numbers, they may not prevent virus transmission, as this can occur even at low aphid densities. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Inspect the crop regularly from early flowering until pod formation. Colonies tend to appear on the headlands first.

Access aphid monitoring tools via: **ahdb.org.uk/pests**

AHDB Pest Bulletin provides monitoring and forecasting information for this pest.

Thresholds

In beans, immediate treatment is justified when 10% of plants are infested. However, treatment when 5% of plants are infested can help prevent virus infection.

In sugar beet, treatment is only justified on backward or stressed crops with more than 100 aphids per plant (averaged across the field and not just on headlands).

Insecticide resistance

None known.

Buckthorn–potato aphid *Aphis nasturtii*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	Sugar beet	Vegetable brassicas

Importance

Buckthorn–potato aphid is a relatively minor pest of potato. Populations rarely grow large enough to cause economic damage through direct feeding. However, very heavy infestations can seriously damage the haulm and reduce yields. The aphid can also transmit non-persistent viruses, such as *Potato virus Y* (*PVY*) and *Potato virus A* (*PVA*). It is thought to be a poor vector of the persistent virus *Potato leafroll virus* (*PLRV*).

Risk factors

- Warm conditions in late spring/early summer can promote large populations
- Most direct damage is caused during tuber bulking in late July and August

Life cycle, identification and symptoms

The wingless adult is relatively small (1–2 mm) and bright yellow-green.

1. Eggs overwinter on buckthorn.
2. Winged adults move into crops in May/June and reproduce throughout the summer.
3. Winged adults migrate to buckthorn to lay eggs.

PVY infections result in leaf drop streak, whereby the lower leaves develop black streaks on their underside veins and eventually collapse – hanging off the stem by a thread. Younger leaves may develop necrotic spotting.

PVA infections usually cause mild mosaic symptoms.

Management

Non-chemical control

Natural enemies include parasitic wasps, ladybirds, hoverflies, lacewings and insect-pathogenic fungi, which may help control aphid numbers. However, they may not be effective in preventing virus transmission, as this can occur even at low aphid densities. Use the SAFE approach to encourage natural enemies – see pages 185–186.

The use of seed potatoes certified by the British Seed Potato Classification Scheme reduces the virus risk and its subsequent spread by aphids. Potato varieties differ in their susceptibility to aphid infestation and virus infection. If the crop is grown in a high-risk area, seek expert advice about which crop variety to choose.

Monitoring

Buckthorn–potato aphids are rarely caught in suction traps, so winged migration data is not available.

Thresholds

None established. Control measures are usually unwarranted.

Insecticide resistance

None known.

Buckthorn–potato aphids

Symptoms of *Potato virus Y* on the leaf

Buckthorn–potato aphid damage

Cabbage whitefly *Aleyrodes proletella*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Cabbage whitefly is an important pest of brassica crops, particularly kale and Brussels sprout. The presence of nymphs (scales), adults, and waste products (mainly honeydew, which can lead to the development of mould) can cause contamination issues and reduce quality. A combination of climate change, removal of certain active ingredients, insecticide resistance and later crop harvest times has led to this pest becoming an increasing problem in recent years.

Risk factors

- Later-harvested crops are at increased risk

Life cycle, identification and symptoms

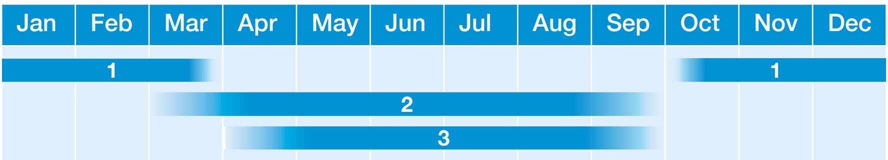
The adults are small, white moth-like insects, about 1.5 mm long, with two pairs of black spots on the forewings.

The eggs are pale, elongated cylinders less than 0.1 mm in diameter, laid in full or partial circles.

The larvae are flat, oval, semi-transparent scales from 0.3–1 mm in length.

The pupae are off-white-to-brown flattened scales, with eyes visible in the later stages.

All life stages are associated with circular deposits of pale wax, which can signify pest presence.



1. Whiteflies overwinter, mainly as adult females in sheltered locations.
2. Adults migrate, often in substantial numbers, when temperatures are above 8°C. As temperatures rise, females lay eggs on leaves.
3. The larva has limited mobility and feeds on the leaf on which it was laid. After three moults, the larva pupates.

Cabbage whiteflies are capable of multiple (two to five) generations per year in the UK, with reproduction ceasing in late September. The rate of development and the start of reproduction are determined by ambient temperature, which ultimately dictates the number of generations and the size of the population.

Management

Non-chemical control

Natural suppression by whitefly predators is unlikely to provide substantial control in most crops. Specialist whitefly natural enemies include parasitoid wasps (*Encarsia inaron*, *Encarsia tricolor*, *Euderomphale chelidonii*), a ladybird (*Clitostethus arcuatus*) and a fly (*Acletoxenus formosus*). Generalist predators of aphids will also feed on whiteflies in the absence of their primary prey. Use the SAFE approach to encourage natural enemies – see pages 185–186.

There may be some potential for inundative releases of parasitoids to provide control in crops. The potential for using biopesticides (for example, fungal pathogens) to reduce whitefly populations has yet to be explored.

In season-long organic Brussels sprout trials in Germany, crop covers reduced whitefly infestations by up to 71%. Fine mesh netting (0.8 x 0.8 mm) reduced or delayed immigration, even with periodic cover removal for weeding. There is potential to disrupt pest infestations through targeted short-term covering after planting out.

Although there is some evidence of host–plant resistance to whitefly in some brassicas, resistant kale and Brussels sprout varieties are not currently available.

Cabbage whiteflies

Monitoring

Although it is possible to capture adult whiteflies on blue or yellow sticky traps, within-crop monitoring is probably the most effective approach.

Thresholds

None established.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

Currant–lettuce aphid *Nasonovia ribisnigri*

Crops affected

Alliums	Carrots	Cereals	Field beans	**Lettuce**
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

The currant–lettuce aphid is the most important foliage aphid on lettuce. Even small numbers can contaminate plants and affect marketability. Rapid development of colonies causes plants to become stunted. In some cases, large populations may result in dead hearts on young plants. Usually, this species does not transmit *Lettuce mosaic virus*.

Risk factors

- These aphids prefer to feed in the centre of the plant and can be extremely difficult to control once the lettuce plant has hearted

Life cycle, identification and symptoms

Adult wingless currant–lettuce aphids are 1–3 mm long and green-to-yellow or pink in colour. They have a shiny abdomen with a dark green-to-black pattern on the upper surface. The two long tubes (siphunculi) at the rear end are pale with dark tips.

The winged form has black siphunculi and antennae and a clear black pattern on the abdomen.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		2		3			4		5		1

1. The aphid usually overwinters as an egg on currant or gooseberry bushes.
2. Eggs hatch in March/April and colonies form on the tops of the young shoots.
3. In May/June, winged aphids migrate to lettuce and wild hosts.
4. Several generations occur on late summer/early autumn hosts.
5. During October/November, winged aphids migrate back to the winter hosts and lay eggs. In warm locations, the mobile stages can survive and slowly reproduce on wild hosts throughout the winter.

Management

Non-chemical control

The mobile forms are attacked by several natural enemies, including ladybirds, hoverflies and lacewings. Use the SAFE approach to encourage natural enemies – see pages 185–186.

To date, biological control with natural enemies has not been evaluated comprehensively in the UK, but the efficacy of several biopesticides is being evaluated.

Some lettuce cultivars with complete resistance to currant–lettuce aphid have been available for several years. However, in recent years, some populations have overcome this form of resistance.

Monitoring

Crop inspection is the best way to monitor currant-lettuce aphids because they tend to be caught in low numbers in suction and water traps.

AHDB Pest Bulletin provides monitoring and forecasting information for this pest.

Thresholds

None established.

Insecticide resistance

Resistance to pirimicarb and pyrethroid insecticides was detected in some UK field populations some years ago. However, the resistance does not appear to have had a major effect on levels of control in the field.

Currant–lettuce aphids on lettuce

Currant–lettuce aphid nymph

Winged currant–lettuce aphid

Currant–lettuce aphids on lettuce

Field thrips *Thrips angusticeps*

Crops affected

Alliums	Carrots	Cereals	**Field beans**	Lettuce
Oilseeds	**Peas**	Potatoes	**Sugar beet**	Vegetable brassicas

Importance

Field thrips affect pea and bean crops from early emergence throughout the growing season. They feed inside the tightly rolled leaves of the growing point. They also damage sugar beet foliage.

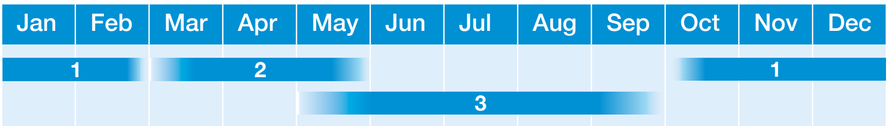
Risk factors

- Periods of slow growth in cold, dry springs, especially on stony soils, increase risk
- In good conditions, crops usually tolerate damage and grow away

Life cycle, identification and symptoms

Adult field thrips and pea thrips are indistinguishable without microscopic examination. They are dark, shiny and narrow-bodied, and reach about 2 mm in length. Two pairs of wings, usually folded along the back, are used to migrate large distances.

Minute, kidney-shaped eggs are embedded into the tissues of flowers and pods. The immature stages are similar in shape to the adults, but have no wings and are bright yellow with a conspicuous black tip at the rear end.



1. Overwinter in soil as short-winged, flightless adults
2. Emerge from soil to feed on young crops
3. Adult field thrips fly to other crops

Mottled patches and distortions on leaf surfaces are a symptom of thrips damage. On beans, the leaves may appear shiny and speckled, with sooty black markings. The undersides of bean leaves develop a rusty-brown discolouration. On peas, field thrips cause the foliage to thicken and pucker, with a translucent spotting developing on the surface of leaves.

In many situations, peas and beans outgrow the initial attack. However, occasionally, when the attack is severe, peas may produce blind shoots that form no flowers, develop multiple secondary shoots and develop as small bushy plants. This is called ‘pea dwarfing syndrome’ and plants will not recover fully.

Bean leaves may die off completely and severely arrest the growth for a week or two.

Management

Non-chemical control

In high-risk areas, sow late-emerging crops.

Thrips are predated by spiders, ladybirds, predatory flies and lacewings. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Crops should be monitored frequently, from emergence. Carefully unfold the leaflets of affected seedlings. In peas, the period from pod emergence until the pods are full is important. Examining late-emerging bean crops is often unnecessary, as they usually escape damage.

Thresholds

Treatment in peas and beans is justified as soon as damage is seen. In beans, since most damage occurs while the crop is young, treatment after mid-May is not worthwhile.

Insecticide resistance

There is no evidence of resistance in this species.

Field thrips (adult)

Damage caused by field thrips

Grain aphid *Sitobion avenae*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	Sugar beet	Vegetable brassicas

Importance

Grain aphid is the main vector of *Barley yellow dwarf virus* (*BYDV*) in the east, middle and north of the UK, causing yield losses of up to 2.5 t/ha. Even very small populations, which may go unnoticed, can transmit *BYDV* and cause economic losses. The aphid also causes direct feeding damage and indirect damage by honeydew secretion during feeding, which encourages sooty moulds to develop and provides a sugar source for flies, including some pest species.

Grain aphid is an efficient vector of *Potato virus Y* (*PVY*). Migration during late June and early July poses the greatest risk of a high incidence of viruses within crops. They can occur in potato crops in extremely high numbers in summer, when they migrate from desiccating cereal crops into potato fields in search of food.

Risk factors

Virus (*BYDV*) losses

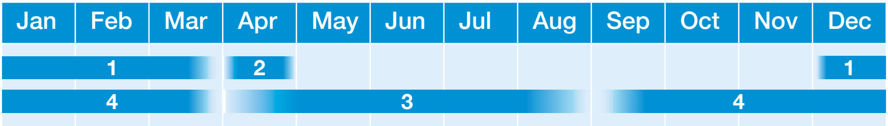
- Early sown winter cereal crops tend to be the highest risk
- Risk is greater in mild winters, as winged aphids migrate later into the season. Spring crops may be vulnerable following mild winters
- *BYDV* is most damaging in cereals if infection occurs before growth stage 31
- The presence of grass weeds, other cereal crops and volunteers increases the risk of virus transmission
- Fields in landscapes with a large amount of grassland and coastal fields in the South West are also at higher risk

Direct feeding damage (summer)

- The earlier senescence of winter barley puts it at lower risk
- Crops affected by drought, pests and diseases suffer more
- Dry, settled weather during early grain filling increases risk
- Outbreaks tend to occur after colder winters, which reduce natural enemy populations more than populations of these cold-hardy aphids
- This species may also infest sweetcorn

Life cycle, identification and symptoms

The grain aphid is 1.3–3.3 mm long, ranges from green to reddish-brown to almost black and has long, yellow legs with dark patches. The siphunculi (at the rear) are black.



1. Adults overwinter on crops and grasses and do not have an alternative woody winter host.
2. Fresh migrations infest crops from April. During dry, settled weather, numbers can increase rapidly.
3. Direct feeding is a risk from April until August. Only very severe infestations produce visible symptoms in crops, with leaves turning yellow and senescing prematurely.
4. In autumn, winged forms move into newly emerged crops. *BYDV* is a risk from September until around March (before growth stage 31). The initial symptoms appear as individual plants scattered throughout the crop with bright yellow upper leaves. As infection spreads, larger patches of bright yellow and severely stunted plants appear.

Grain aphids

Grain aphids

Grain aphids

Grain aphids

Symptoms of *BYDV* infection

Some grain aphids have a sexual life cycle, with eggs laid in the autumn on grasses and cereals. These eggs can survive through the winter and hatch in spring.

Management

Non-chemical control

BYDV-resistant varieties are available for some crops. If a spring barley crop follows a mild winter or is in a milder area, it may be worthwhile choosing a moderately resistant variety (see AHDB Recommended List).

Autumn/winter

Ground beetles, spiders and parasitoids are natural enemies that are active in autumn and winter, although the latter may only be active in mild winter weather. Web-building money spiders are present in high numbers in the autumn and their webs capture immigrating aphids. Use the SAFE approach to encourage natural enemies – see pages 185–186.

If high levels of aphid-infested grasses, especially annual meadow grass, are present in the stubble, a desiccant herbicide or ploughing may be beneficial to remove this green bridge. However, the risk of infestation by winged aphids in the autumn is lower following minimum tillage – more so if the straw is left, compared with ploughing. Delaying sowing, so that crops emerge after the end of the aphid migration (usually early November), will also reduce *BYDV* risk, but this is not always practical.

Spring/summer

Early in the aphid population growth phase, the generalist predators (spiders and beetles) provide background control, helping to prevent aphids from reaching economically damaging levels. Once aphid numbers build up, aphid-specific predators, such as hoverflies, ladybirds, lacewings and parasitic wasps, become more important.

Grass banks and field margins provide overwintering habitats, alternative foraging sites and refuges for natural enemies in summer. While grasses can harbour infective aphids, they also help maintain populations of parasitic wasps and facilitate faster colonisation in spring.

Monitoring

BYDV

National monitoring provides information on aphid migration. Temperature (degree-day) models are available to predict the appearance of secondary generations following migration.

Access aphid monitoring tools via:
ahdb.org.uk/pests

Direct feeding damage (summer)

To monitor direct feeding damage, check for aphids on the leaves, initially at about the same time that cereals are coming into ear. Individuals move up to the ears during grain filling and feed from the phloem supply to the grain.

Thresholds

BYDV

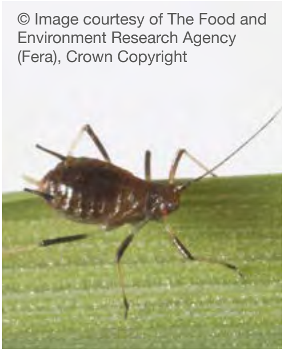
Since there is insufficient information on the prevalence of virus-carrying aphids, assume grain aphids carry *BYDV*. Although no treatment thresholds exist, use temperature models (for example, the AHDB *BYDV* Tool to time any necessary treatment).

Direct feeding damage (summer)

- Before the start of flowering (growth stage 61): 50% of tillers infested
- After the start of flowering (growth stage 61) to 2 weeks before end of grain filling: 66% of tillers are infested and aphid numbers are increasing

Insecticide resistance

Moderate levels of pyrethroid resistance are widespread in the UK.



Grain aphid

Grain aphids

Lettuce root aphid *Pemphigus bursarius*

Crops affected

Alliums	Carrots	Cereals	Field beans	**Lettuce**
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Infestations of the lettuce root aphid can reduce yield and marketability. Severe infestations can also lead to significant crop losses.

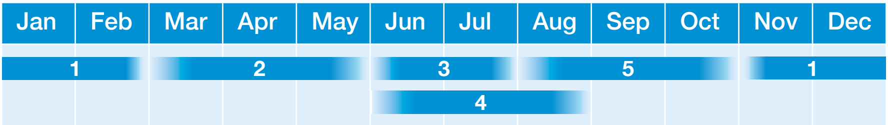
Risk factors

- Symptoms are more severe in dry seasons because aphids damage roots and reduce water uptake

Life cycle, identification and symptoms

Adult winged lettuce root aphids are 2 mm long and have a dark head bearing short antennae. The thorax is dark brown or black and the abdomen is brownish-orange with a slight powdering of wax.

Adult wingless lettuce root aphids have a yellow head with green-grey antennae that are much shorter than the body. The body is yellowish-white and often covered in large quantities of white-grey wax. There are no siphunculi.



1. The aphid overwinters as an egg on Lombardy and black poplar trees.
2. Eggs hatch into nymphs. These feed on developing petioles, which enlarge to form galls within which the nymphs live and mature to produce a further generation of aphids.
3. Winged aphids are present over a 4–5 week period in late June or early July. These migrate to lettuce and wild hosts, where they reproduce asexually.
4. The wingless progeny migrate to the roots and produce multiple generations. However, their presence is not often apparent until plants wilt. Large infestations cause desiccation and yellowing.
5. Winged aphids migrate back to host poplar trees.

Management

Non-chemical control

Irrigation can be highly beneficial for crops showing signs of damage.

Lombardy poplars should not be planted (for example, as windbreaks) close to areas of lettuce cultivation.

Natural enemies, including ladybirds and hoverflies, attack the aphids in galls on poplar and on lettuce roots. Use the SAFE approach to encourage natural enemies – see pages 185–186.

There are no tested biological control agents or biopesticides available.

Cultivars of lettuce with almost complete resistance to lettuce root aphid (Avoncrisp and Avondefiance) were developed in the UK, but the material has not been used to develop more modern cultivars.

Monitoring

AHDB Pest Bulletin provides forecasting information for this pest.

Thresholds

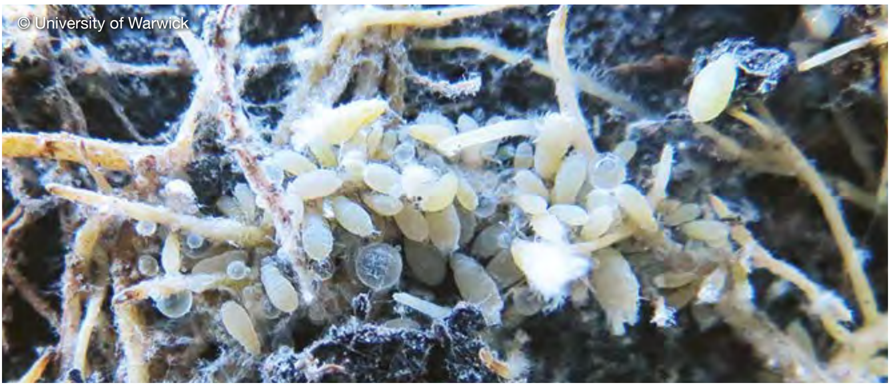
None established.

Insecticide resistance

None known.

Lettuce root aphid gall on poplar

Lettuce root aphid damage



Lettuce root aphids

(Mealy) cabbage aphid *Brevicoryne brassicae*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

The mealy cabbage aphid is a serious pest of vegetable brassicas, where infestation leads to distorted foliage and contamination of produce by aphids, wax, cast skins and honeydew. Severe infestations reduce yield and may even kill young plants. In vegetable brassicas, it is also an important vector of several viruses, including *Turnip mosaic virus* (*TuMV*) and *Cauliflower mosaic virus* (*CaMV*).

Mealy cabbage aphid is not usually a serious pest of oilseed rape.

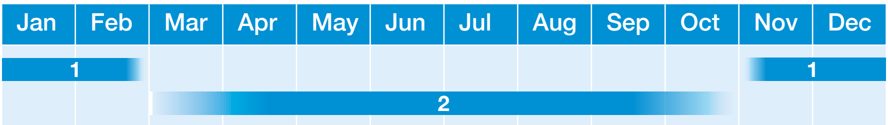
Risk factors

- Spring oilseed rape is at highest risk, although mild winters can result in damaging infestations on winter oilseed rape
- Hot, dry summers can result in large populations

Life cycle, identification and symptoms

Wingless aphids are up to 2.6 mm long, green and covered with a greyish-white mealy wax, with short, transverse, dark bars on the upper side of the thorax and abdomen.

Winged aphids have a dark head and thorax.



1. This species overwinters on brassica crops and wild hosts, mostly in their active stages, although some may overwinter as eggs.
2. The production of winged forms allows this species to move to new brassica crops, multiplying rapidly in hot, dry conditions.

Initial symptoms in vegetable brassicas are small, bleached areas on the leaves that become yellowish and crumpled. Young plants can become stunted and die, especially in unfavourable weather.

Early infestations in oilseed rape occur under leaves, but later infestations move to developing flowers and pods and can result in dense colonies. Autumn feeding often causes leaf distortions, twisting of the midrib and chlorotic patches. The crop usually recovers in the spring. In spring oilseed rape, serious infestations can cause pod distortions and yield loss.

On all crops, *TuMV* and *CaMV* cause leaf mottling and vein clearing, stunting, and black mottling and streaking on stems.

Management

Non-chemical control

Natural enemies include parasitic wasps (for example, *Diaeretiella rapae*), ladybirds, hoverflies, lacewings, several predatory flies, spiders and insect-pathogenic fungi. Providing habitats that encourage the presence of these natural enemies may help control aphid numbers – see pages 185–186. However, they may not prevent virus transmission because this can occur even at low aphid densities.

Biopesticides are being evaluated for control of this pest.

Monitoring

Access aphid monitoring tools via:
ahdb.org.uk/pests

AHDB Pest Bulletin provides monitoring information for this pest.

Thresholds

- Winter oilseed rape: >13% of plants infested before petal fall
- Spring oilseed rape: >4% of plants infested before petal fall
- Vegetable brassicas: none established

Insecticide resistance

None known.

Mealy cabbage aphids

Mealy cabbage aphids on oilseed rape

Mealy cabbage aphids on a vegetable brassica crop

Onion thrips Thrips tabaci

Crops affected

Alliums	Carrots	Cereals	**Field beans**	Lettuce
Oilseeds	**Peas**	Potatoes	**Sugar beet**	**Vegetable brassicas**

Importance

In the UK, onion thrips particularly affect leek, salad onion, stored cabbage and sugar beet. Obvious thrips presence/feeding damage can make crops unacceptable for market. Onion thrips are a difficult target for insecticides that work by contact action. This may be particularly true for the larvae, which do not move onto the higher and more exposed parts of the plant.

Risk factors

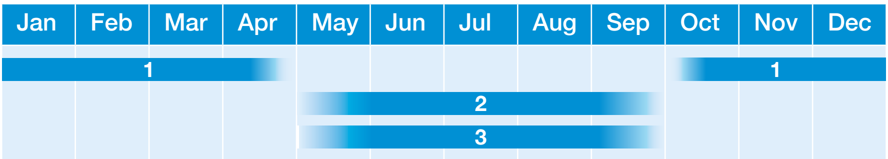
- Warm, dry conditions promote fast larval development and are ideal for flight
- Very mild winters may favour the continued development of onion thrips inside stored cabbage maintained in ambient stores

Life cycle, identification and symptoms

The adult onion thrips are approximately 1 mm in length. They are usually brown, with two pairs of wings, fringed with long hairs.

The eggs are minute (0.3 mm long), kidney-shaped and white/yellow in colour.

Larvae are yellow/cream and start around 0.5 mm in length.



1. In the UK, onion thrips overwinter in the adult stage and prefer host vegetable crops, such as leek. However, they will also overwinter in other locations, such as on winter cereals.
2. Once temperatures rise, female thrips lay eggs on either the overwintering host (if it remains a suitable food source) or moves to an alternative host.
3. Following egg hatch, there are two active larval stages and two inactive stages (pre-pupa and pupa). Pupation usually takes place in the ground.

A generation (egg to adult) takes about 52 days at 12.5°C and 15 days at 25°C.

Feeding by adult and larval thrips damages the host plant via direct removal of cell contents. As individual plant cells are killed, scarring of the leaf is observed in the form of silvering. On cabbage, feeding by thrips can result in small, brownish-grey growths on the leaf surface, as well as silver-coloured lesions.

Management

Non-chemical control

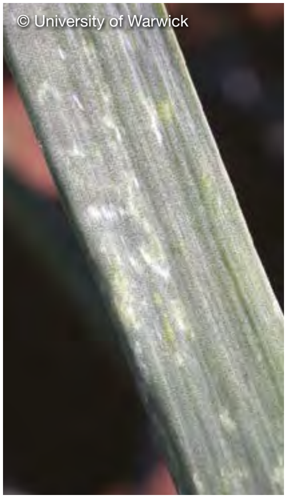
There is a consensus (across many countries) that irrigation helps reduce thrips populations.

In some situations, resistant onion varieties provided more effective control than insecticides in the USA. However, there has been no comprehensive survey of resistance in UK-grown cultivars.

Intercropping in onions has reduced infestations by at least 50% in some trials. Leek undersown with clover has also shown excellent potential for control. For both approaches, competition between the crop and companion plants may limit their usefulness, along with associated costs.

Although thrips control has been achieved with predators, this is mainly in protected crop environments, with augmentative or inundative techniques. The technique has not been evaluated outdoors in the UK. The potential of entomopathogenic nematodes has been investigated, but no evidence of thrips control was found in leek crops.

Onion thrips larva



Onion thrips damage

Monitoring

Adult onion thrips can be monitored most effectively with blue or white sticky traps. It may be sufficient to trap thrips at one or two locations within a region, as the pattern of activity appears to be consistent in any year. Direct crop examination of damage (which is easier than counting thrips) is also worthwhile. Inspection of young leaves provides an indication of recent/current activity.

Thresholds

Although traps provide an early warning of activity, they do not provide a reliable prediction of infestation severity.

Insecticide resistance

Resistance to pyrethroid insecticides in field populations of onion thrips has been confirmed in the UK.

Pea aphid *Acyrthosiphon pisum*

Crops affected

Alliums	Carrots	Cereals	**Field beans**	Lettuce
Oilseeds	**Peas**	Potatoes	Sugar beet	Vegetable brassicas

Importance

A major pest of peas and beans, pea aphid can cause flower abortion and misshapen pods, which fail to fill, and reduce yields.

The pea aphid also transmits viruses, including *Pea seed-borne mosaic virus* (*PSbMV*), *Pea enation mosaic virus* (*PEMV*) and *Bean leafroll virus* (*BLRV*). *PSbMV* affects quality in vining peas and the maintenance of disease-free seed stocks. In severe cases, *PEMV* can cause large yield reductions.

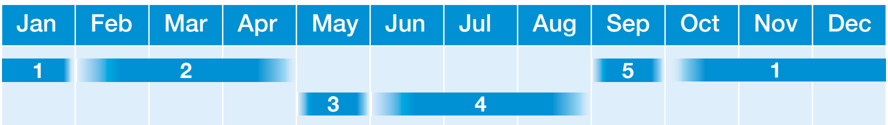
Additionally, the honeydew produced by the pest can cause contamination issues leading to the growth of saprophytic fungi and may increase the cost of cleaning vining machinery.

Risk factors

- Combining peas are at highest risk from direct damage once flowering has started. Control after the development of the fourth pod-bearing node will not normally increase yield
- Overwintering crops, such as clover and lucerne, in neighbouring fields can increase the risk of aphids migrating into the crop in May
- Crops are most at risk from *PEMV* if it is transmitted before flowering occurs
- *PSbMV* is most likely to become established via infected seed. The virus is transmitted by aphids in early spring

Life cycle, identification and symptoms

The pea aphid is large, 2.5–5.0 mm long, pale green or pink with red eyes, with a pear-shaped body, long antennae and long legs.



1. Eggs overwinter on forage crops, such as lucerne, trefoils and clover. Active stages may overwinter in mild years.
2. Eggs hatch and wingless generations reproduce on overwintering plants.
3. Winged forms migrate to pea and legume crops.

4. Aphids feed and reproduce rapidly on peas and legumes, with highest numbers usually seen between late June and early July.
5. Winged forms migrate to overwintering sites.

PSbMV causes stunting, shortening and downward rolling of leaflets, vein clearing and apical malformation (rosetting). Flowers and pods may be distorted. A white blistering may also develop over the seed coats as the peas mature, giving them a ‘tennis-ball’ marking.

PEMV causes vein clearing and the formation of translucent spots, which are apparent when infected leaves are held up to the light. Development of stipules (the leaf-like structures at the base of leaves) is often retarded, while leaflets become crinkled and may contain necrotic spots. Plant tops often become yellow and mottled, with distorted leaves. Pods may be severely malformed and fail to fill. At an advanced stage of infection, scaly leaf-like structures (enations) may appear. These are small, irregular, protruding ridges of plant tissue found on pods and the underside of leaves. Further symptoms of an advanced infection are the cessation of terminal growth, the disappearance of axillary buds and impairment of flower set.

BLRV causes leaf yellowing, upward leafrolling and a decrease in the number of pods in field beans.

Symptoms of *Pea seed-borne mosaic virus* infection

Pea aphids

Pea aphids

Pea aphids

Pea aphids

Management

Non-chemical control

Avoid growing peas or beans in fields with nearby concentrations of clover or lucerne.

Predators, such as ladybirds and hoverfly larvae, may help control pest populations, but the presence of hoverfly larvae can contaminate vining peas. Other natural enemies include spiders, fungal pathogens and parasitoids. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Ensure seed stock is free of *PSbMV* to minimise virus transmission risk.

Monitoring

Generally, during May to July, consider control if there is a light or general pea aphid distribution and humid weather, or if breeding colonies are evident.

Access aphid monitoring tools via:
ahdb.org.uk/pests

Thresholds

- Combining peas: 20% or more of plants infested at early flowering
- Vining peas: 15% or more of plants infested
- Field beans: none established

Virus transmission can occur even with low aphid numbers. If crops are in high-risk virus areas, control aphids as soon as colonies are present, particularly if this occurs before flowering.

There is little benefit of treating combining peas infested after the development of the fourth pod-bearing node.

Insecticide resistance

None known.

Symptoms of *Pea enation mosaic virus* (*PEMV*) infection

Symptoms of *Bean leafroll virus* (*BLRV*) infection

Pea thrips *Kakothrips pisivorus*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	**Peas**	Potatoes	Sugar beet	Vegetable brassicas

Importance

Pea thrips attack pea crops during and after flowering, causing damage to the pods.

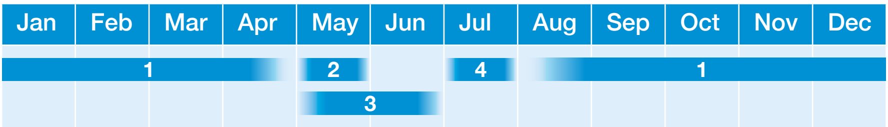
Risk factors

- Periods of slow growth in cold, dry springs, especially on stony soils, increase risk
- In good conditions, crops usually tolerate damage and grow away

Life cycle, identification and symptoms

Adult pea thrips and field thrips are indistinguishable without microscopic examination. They are dark, shiny and narrow-bodied and reach about 2 mm in length. Two pairs of wings, usually folded along the back, are used to migrate large distances.

Minute, kidney-shaped eggs are embedded into the tissues of flowers and pods. The immature stages are similar in shape to the adults, but have no wings and are bright yellow with a conspicuous black tip at the rear end.



1. Nymphs overwinter in soil.
2. Nymphs pupate.
3. Winged adults emerge and move into crops. Eggs are laid in flowers and on pods. Hatching nymphs feed on the crop. Populations peak mid-June.
4. Nymphs descend into soil.

Compared with field thrips, pea thrips attack later in the season and cause distinctive silvery blemishes on the surfaces of pea pods.

Management

Non-chemical control

In high-risk areas, sow late-emerging crops.

Thrips are predated by spiders, ladybirds, predatory flies and lacewings. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Make frequent examinations of the crop, especially after the start of flowering until pods are full.

Thresholds

Treatment is justified as soon as damage is seen.

Insecticide resistance

There is no evidence of resistance in this species.

Thrips

Peach–potato aphid *Myzus persicae*

Crops affected

Alliums	Carrots	Cereals	Field beans	**Lettuce**
Oilseeds	Peas	**Potatoes**	**Sugar beet**	**Vegetable brassicas**

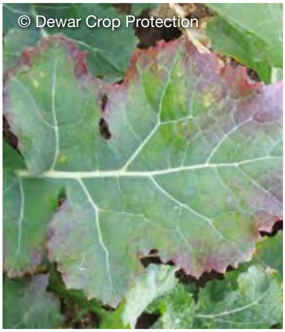
Importance

The peach–potato aphid is an important pest of potatoes, oilseed rape, vegetable brassicas, sugar beet and lettuce. Transmission of viruses can cause serious economic damage, but only heavy infestations cause direct feeding damage.

This aphid is the most important vector of *Turnip yellows virus* (*TuYV*), *Potato leafroll virus* (*PLRV*), *Potato virus A* (*PVA*) and *Potato virus Y* (*PVY*). It also transmits *Cauliflower mosaic virus* (*CaMV*), *Beet yellows virus* (*BYV*), *Beet chlorosis virus* (*BChV*) and *Beet mild yellowing virus* (*BMYV*). The average yield loss from *TuYV* in oilseed rape is 15%, but it can be as high as 30%.

Risk factors

- Early season virus transmission carries the greatest risk to the crop
- Infestations can be more severe if alternative hosts (for example, overwintered brassicas, sugar beet and oilseed rape) are in neighbouring fields
- Mild winter conditions increase the risk of a larger and earlier spring migration and a greater level of virus spread in early sown crops
- Cooler winters, particularly in northern areas, can lead to a smaller spring migration and larger summer migration, meaning late-sown crops are at higher risk from virus transmission
- In oilseed rape, early sown winter crops tend to be at greatest risk during warm autumns, while later-sown spring crops tend to be at greater risk after mild winters
- Mild winters and warm springs can increase the risk of virus incidence in sugar beet



Symptoms of *Turnip yellows virus* infection

Symptoms of infection with *Potato virus Y* on the leaf

Life cycle, identification and symptoms

The wingless peach–potato aphid is medium-sized (1–2 mm long) and ranges from pale green-to-pink or almost black. The winged form is a similar size, but has a black central abdominal patch on the upper surface with a pale underside.

1. Asexual females overwinter in brassicas, herbaceous crops and weeds. A small proportion of eggs overwinter on peach and nectarine trees. Cold weather reduces survival of mobile stages.
2. Adults migrate to and infest various summer crops, including potato. They can multiply extremely quickly, with populations usually peaking in early to mid-July. A further, smaller, peak occasionally occurs in late August/September.
3. In mild autumns, adults infest oilseed rape and vegetable brassicas, transferring viruses.

Symptoms of *Potato leafroll virus* infection

Different colours of peach–potato aphid

Symptoms of *Beet yellows virus* (top leaf) and *Beet mild yellowing virus* (bottom leaf) infection

Peach-potato aphid

In oilseed rape, symptoms of *TuYV* infection do not usually show until late spring/early summer, appearing as purple tingeing of leaf edges and pods. This is easily mistaken for frost damage, nutrient deficiency or other stresses.

In vegetable brassicas and lettuce, the peach–potato aphid is a contaminant, virus vector and may cause considerable distortion of the plant following severe infestations.

In sugar beet, *BYV* symptoms are characterised by diffuse chlorotic patches on mature leaves, which expand and coalesce. Leaves may be subject to infection by secondary pathogens, such as Alternaria. Leaves also become thickened and brittle, snapping crisply when broken.

In potato, *PVY* infections result in leaf drop streak. Here, the lower leaves develop black streaks on their underside veins and eventually collapse, hanging off the stem by a thread. Younger leaves may develop necrotic spotting.

Aphid-vectored *PLRV* infections result in the margins of young leaflets rolling upwards and inwards – a pattern more pronounced at the leaflet base. Infected leaves may also develop a purple discolouration.

Symptoms of secondary (tuberborne) infections of these viruses may differ from the primary infections described above.

Symptoms of infection with *Potato virus Y*

Management

Non-chemical control

Natural enemies include parasitic wasps, ladybirds, predatory flies, spiders, ground beetles, rove beetles, lacewings and insect-pathogenic fungi. Providing habitats that encourage the presence of these natural enemies may help control aphid numbers – see pages 185–186. However, natural enemy activity may not prevent virus transmission, which can occur even at low aphid densities.

Using seed potato certified by the British Seed Potato Classification Scheme reduces the virus risk and its subsequent spread by aphids. Potato varieties differ in their susceptibility to aphid infestation and virus infection. If the crop is grown in a high-risk area, seek expert advice about which crop variety to choose.

Oilseed rape varieties with resistance to *TuYV* are available (see AHDB Recommended List).

Early sowing of sugar beet means it is less likely to be affected because older leaves are less palatable to the aphids. Managing leaf growth on beet clamps can remove sources of infection.

Monitoring

Access aphid monitoring tools via: **ahdb.org.uk/pests**

AHDB Pest Bulletin provides monitoring information for this pest.

Thresholds

Sugar beet: one green wingless aphid for every four plants, up to the 12-leaf stage.

No satisfactory thresholds exist for other crops. If aphids are present, assume they carry virus.

Insecticide resistance

There are three different mechanisms of insecticide resistance in peach–potato aphid in the UK – these affect organophospates, carbamates and pyrethroids. Neonicotinoid resistance has been detected in southern mainland Europe.

Potato aphid *Macrosiphum euphorbiae*

Crops affected

Alliums	Carrots	Cereals	Field beans	**Lettuce**
Oilseeds	Peas	**Potatoes**	**Sugar beet**	**Vegetable brassicas**

Importance

Adult potato aphid

Although the potato aphid is widespread most years, it rarely results in epidemics.

Yield reduction is mainly associated with the transmission of viruses, such as *Potato virus Y* (*PVY*) and *Potato leafroll virus* (*PLRV*), but also sap-feeding, under heavy infestations.

It is usually the most common aphid species found on potato and can persist late into autumn. On this crop, this aphid tends to multiply on the flowers and shoot tips. Even moderate numbers can produce appreciable yield reductions.

Although potato aphid may infest vegetable brassicas and lettuce, it is generally a contaminant, rather than a source of severe damage.

Sugar beet does not usually suffer from direct feeding damage, but potato aphid can transmit *Beet mild yellowing virus* (*BMYV*) and *Beet yellows virus* (*BYV*), although less efficiently than peach–potato aphid.

Risk factors

- Damage in potatoes is greatest when aphid numbers peak after mid-July
- Risk of virus transmission in sugar beet is greater in crops that have fewer than 12 true leaves; older crops become unpalatable

Life cycle, identification and symptoms

Adult potato aphid wingless forms are 2.5–4 mm long, with a pear-shaped green-to-pinkish-red body, red eyes and a dark stripe running down the back. They have long legs and antennae at least as long as the body. Winged adults have a yellowish-brown head and green thorax.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	1	1	2	2	4		5		1	1
				3	3	3	3	3	3		

1. Wingless adults and immature stages overwinter on weeds, potato sprouts, rose and protected lettuce.
2. Winged forms migrate to summer crops.
3. Wingless forms feed and reproduce on crops.
4. If heavy infestations occur, a further migration is common.
5. A small autumn migration may occur.

With heavy infestations on potato, aphid feeding can result in 'false top roll' symptoms (upper leaves roll). Unlike *PLRV*, these symptoms occur in distinct patches earlier in the summer, with aphids or their cast skins present.

PVY infections result in leaf drop streak, whereby the lower leaves develop black streaks on their underside veins and eventually collapse – hanging off the stem by a thread. Younger leaves may develop necrotic spotting.

Aphid-vectored *PLRV* infections result in the margins of young leaflets rolling upwards and inwards, particularly at the leaflet base. Infected leaves may develop a purple discolouration. Symptoms of secondary (tuberborne) infections of these viruses may differ from the primary infections described above.

In sugar beet, *BYV* symptoms are characterised by diffuse chlorotic patches on mature leaves, which expand and coalesce. Leaves may be subject to infection by secondary pathogens, such as *Alternaria*. Leaves also become thickened and brittle, snapping crisply when broken.

Management

Non-chemical control

Natural enemies include parasitic wasps, ladybirds, predatory flies, spiders, ground beetles, rove beetles, lacewings and insect-pathogenic fungi. Providing habitats that encourage the presence of these natural enemies may help control aphid numbers – see pages 185–186. Natural enemies may not prevent virus transmission, as this can occur even at low aphid densities. Early sowing of sugar beet can make it less vulnerable because older leaves are less palatable to the aphids.

Monitoring

Access aphid monitoring tools via: **ahdb.org.uk/pests**

AHDB Pest Bulletin provides monitoring information for this pest.

Thresholds

Potatoes: none established. Treat if aphid numbers start to increase rapidly on varieties known to be susceptible to 'false top roll'.

Insecticide resistance

None known.

Rose–grain aphid *Metopolophium dirhodum*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Feeding by rose–grain aphid can result in yield losses of up to 4 t/ha, although losses of 0.25–1 t/ha are more typical. Generally, it is not an important vector of *Barley yellow dwarf virus* (*BYDV*).

Risk factors

- The earlier senescence of winter barley puts it at lower risk
- Plants that are stressed (for example, by drought, or pests and diseases) suffer more because they have lower reserves of soluble stem carbohydrates
- Dry, settled weather during early grain filling increases risk
- Rose–grain aphids tend to be more problematic after hard winters when natural enemies are scarcer

Life cycle, identification and symptoms

Wingless rose–grain aphids are medium-sized, 1.6–3 mm long and light green or, rarely, pink. Green varieties have a bright green stripe down the centre of their back.

Winged forms have a pale yellow-green abdomen with darker green markings.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		2				3			4		1
	5										5

Rose–grain aphid

1. Eggs overwinter on wild and garden roses.
2. Winged forms migrate to crops and reproduce.
3. Aphids feed on the leaves of crops and grasses. Only very severe infestations produce visible symptoms in crops. Infested leaves turn yellow and senesce prematurely.
4. Eggs are laid on wild and garden roses.
5. Adults can overwinter on grasses, but are not normally found in cereals in autumn.

Management

Non-chemical control

Natural enemies include lacewings, ground beetles, soldier beetles, rove beetles, ladybirds, spiders and fungal diseases. Grass banks and field margins provide overwintering habitats, alternative foraging sites and refuges for natural enemies in summer. While grasses can harbour infective aphids, they also help maintain populations of parasitic wasps, facilitating faster colonisation in spring. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Rose–grain aphids

Monitoring

Check lower leaves at about the time the cereals come into ear and also monitor top leaves during later growth stages. Aphids do not move to the ear.

Access aphid monitoring tools via:
ahdb.org.uk/pests

Rose–grain aphids

Thresholds

Before the start of flowering (growth stage 61): 50% of tillers infested.

After the start of flowering (growth stage 61) to 2 weeks before end of grain filling: 66% of tillers are infested and aphid numbers are increasing.

Insecticide resistance

None known.

Rose–grain aphids

Tarnished plant bug *Lygus rugulipennis*

Crops affected

Alliums	**Carrots**	Cereals	Field beans	**Lettuce**
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

Importance

The tarnished plant bug, officially known as the European tarnished plant bug to distinguish it from similar species, is a type of capsid bug. The adults and nymphs feed on leaves, buds and fruits of susceptible plants (carrot, celery, lettuce and other vegetables) and seriously reduce marketability.

It can also damage sugar beet, causing distortion of the growing point, multiple crowning and poorly yielding plants.

Other species of capsid may also cause damage.

Risk factors

- The presence of alternative hosts in nearby fields or field margins may increase risk
- Damage may be more severe on headlands, owing to adults overwintering in hedgerows

Life cycle, identification and symptoms

Adult bugs are 5–6 mm long, oval-shaped and brownish-green with dark markings. They usually appear to be 'tarnished'. They have a small head with a pair of long, jointed antennae.

Eggs are elongate and slightly curved. The nymph is green with black spots on its thorax.

1. Adults overwinter on evergreen foliage and in leaf litter.
2. Adults emerge in March/April and feed on plant tissues. Small brown spots appear on young leaves and the area surrounding each feeding site dies. Affected plants may fail to grow properly and plant parts become malformed.
3. Females lay eggs in plant tissue (terminal shoots, buds and fruits).
4. Nymphs feed on plant tissues and develop through six instars. Adults develop by July and continue to reproduce.
5. Another generation is produced in August/September.

In summer, other species of capsid bugs feed on the leaf veins of older plants, causing puckering and yellowing. Close to the puncture site, the tissue is often blackened.

Management

Non-chemical control

Trap crops have been used successfully in strawberry, sometimes in conjunction with vacuuming the trap crop to reduce infestations. Such approaches for field vegetables have not been evaluated.

Some years ago, some variation in susceptibility was identified between carrot cultivars.

Monitoring

Pheromone traps are available to monitor adult tarnished plant bugs.

Blue sticky traps are more effective than yellow sticky traps.

Thresholds

None established.

Insecticide resistance

None known.

Adult capsid bug

Capsid nymph

Capsid bug damage

Willow–carrot aphid Cavariella aegopodii

Crops affected

Alliums	**Carrots**	Cereals	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	Sugar beet	Vegetable brassicas

Importance

Willow–carrot aphids affect carrot, celery, parsnip and parsley. Severe infestations can distort foliage, stunt growth and kill very young plants.

The aphid is also the vector of *Parsnip yellow fleck virus* (*PYFV*) and the two viruses that cause carrot motley dwarf disease. It can also transmit *Carrot red leaf virus* (*CtRLV*), *Parsnip mosaic virus* (*ParMV*) and *Celery mosaic virus* (*CeMV*).

This aphid can also transmit *Potato virus Y* (*PVY*) and *Potato virus A* (*PVA*), although it is less important as a vector than *Myzus persicae*.

Risk factors

- Dry, sunny weather in late May/June favours a large-scale migration to host crops. Conversely, cold, rainy weather inhibits migration
- Nearby umbelliferous plants can act as an alternative host
- Increased risk if virus transmission coincides with an early crop growth stage
- Insecticidal control of the aphids may have little effect on virus transmission

Life cycle, identification and symptoms

The adult wingless form is 1–2.6 mm long, green or yellowish-green, elongate oval and somewhat flattened. There are two tubes (siphunculi) at the rear end, swollen towards the tips. A small outgrowth is present above the tail.

The winged form is darker and has a black patch on the upper surface of the abdomen.

1. The aphid mainly overwinters as eggs around willow buds. In warmer conditions, some overwinter as mobile stages on crops in field storage or on wild hosts.

2. Eggs hatch.

3. The aphids feed and reproduce on willow.

4. Winged aphids migrate to other host plants, including carrot, over a 5–6 week period, usually with a peak in early June. Late seasons can delay migration for 2–3 weeks.

5. Further winged generations disperse to wild hosts.
6. Winged aphids migrate to willow to mate and lay eggs.

Typically, aphids infest carrots at the cotyledon stage, but can also invade older plants. When many are present, the leaves may be discoloured, distorted and shiny from honeydew excretion. The crop may become covered with cast skins. Carrot motley dwarf disease produces a yellow mottling of the leaves and stunts the plants.

Feeding damage may be confused with carrot fly damage and, sometimes, drought stress.

Parsnip yellow fleck virus can cause stunted plants and blackening of the central core.

Winged willow–carrot aphid

Willow–carrot aphids

Management

Non-chemical control

Natural enemies, including ladybirds and parasitoid wasps, attack mobile forms of this pest. Use the SAFE approach to encourage natural enemies – see pages 185–186.

The efficacy of several biopesticides, but not biological control, is under evaluation in the UK.

Monitoring

A day-degree forecast has been developed to predict the start of the migration from willow to carrot and other host plants.

Access aphid monitoring tools via:
ahdb.org.uk/pests

AHDB Pest Bulletin provides monitoring and forecasting information for this pest.

Thresholds

None established.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

Potato leafhoppers (*Edwardsiana flavescens, Empoasca decipiens, Eupterycyba jucunda* and *Eupteryx aurata*)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	Sugar beet	Vegetable brassicas

Four species of leafhopper commonly attack potato, but they seldom cause economic damage.

Leafhoppers are around 5 mm long, with elongated yellow or green bodies and they tend to fly or jump away when disturbed.

The potato leafhoppers are common inhabitants of hedgerows, moving into the crop in early summer to feed on the underside of leaves. They lay pale, slender eggs on stems and leaf veins. Several generations can be completed within a year.

Feeding causes pale speckling of the leaves, while injection of their saliva into the phloem causes 'hopperburn', a yellowing/browning of the foliage.

Severe cases can result in brown, wilting and dying leaves.

Potato leafhopper

Potato leafhopper

Other thrips (*Caliothrips fasciatus*)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

On sugar beet, several thrips feed on mainly young leaves, causing superficial silvering, puckering or reddening. Attacks on still-curled heart leaves can prevent normal growth and leaf expansion. Damage to the hypocotyl near the soil surface is hard to prevent and can cause seedling death. Although *Caliothrips fasciatus* can cause such damage, thrips damage in sugar beet is more commonly caused by field thrips and onion thrips.

Thrips damage in sugar beet

Pests: Flies and sawflies

89 **An introduction to flies and sawflies**

90 **Bean seed flies (*Delia platura and Delia florilega*)**

92 **Beet leaf miner (*Pegomya hyoscami*)**

94 **Brassica leaf miner (*Scaptomyza flava*)**

96 **Brassica pod midge (*Dasineura brassicae*)**

98 **Cabbage root fly (*Delia radicum*)**

102 **Carrot fly (*Psila rosae*)**

104 **Frit fly (*Oscinella frit*)**

106 **Gout fly (*Chlorops pumilionis*)**

108 **Leatherjackets (*Tipula paludosa* and *Tipula oleracea*)**

110 **Onion fly (*Delia antiqua*)**

112 **Orange wheat blossom midge (*Sitodiplosis mosellana*)**

114 **Pea midge (*Contarinia pisi*)**

116 **Saddle gall midge (*Haplodiplosis marginata*)**

118 **Swede midge (*Contarinia nasturtii*)**

120 **Turnip sawfly (*Athalia rosae*)**

122 **Wheat bulb fly (*Delia coarctata*)**

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126 **Minor/emerging pests**

126 Allium leaf miner (*Phytomyza gymnostoma*)

127 Cereal stem sawfly (*Cephus pygmaeus*) and leaf sawflies

127 Yellow wheat blossom midge (*Contarinia tritici*)

An introduction to flies and sawflies

Flies (Diptera)

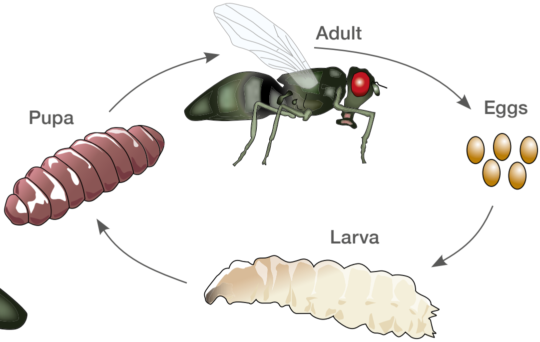
Typically, flies are the most numerous insects found on farmland. Although some are crop pests, many perform important functions: pest control (see page 197), pollination, organic matter recycling and a food source for farmland birds.

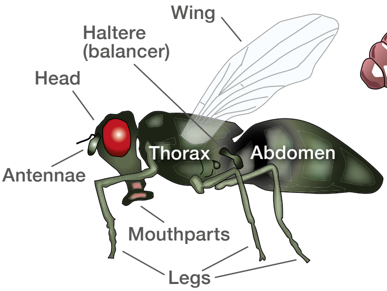
Life cycle

There are four stages to the fly life cycle.

Defining features

Adult flies have a single pair of wings. Fly larvae are mostly legless maggots.



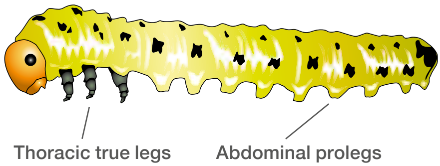


Sawflies (Hymenoptera: Symphyta)

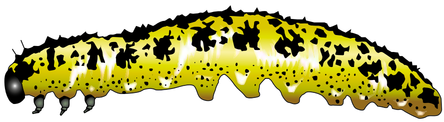
Sawflies are not true flies: they are related to bees, wasps and ants. The adults look similar to wasps, but are distinguished by a broad connection between the abdomen and thorax (unlike the ‘wasp waist’ of other hymenopteran species).

The caterpillar-like larvae have six or more pairs of prolegs on the abdomen, whereas true caterpillars have five pairs or fewer, with the first two abdominal segments being legless. Sawfly larvae also have a smooth head capsule with distinct, small black eyes.

Sawfly larva



Butterfly larva (caterpillar)



Bean seed flies *Delia platura* and *D. florilega*

Crops affected

Alliums	Carrots	**Cereals**	**Field beans**	Lettuce
Oilseeds	**Peas**	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Although adult bean seed flies are common, damage is often localised and sporadic.

In beans, the most serious damage is caused in the spring. Usually, the first sign of damage is the patchy emergence of seedlings. It is impossible to control an infestation at this point. Seeds of other crops are also vulnerable.

Risk factors

- Eggs are preferentially laid in freshly disturbed soil, especially near vegetable or farmyard manure residues
- Any factor that slows down the speed of germination and shoot vigour increases the risk of damage. In particular, these factors include low temperatures and excessively deep sowing
- High levels of moisture are also thought to increase the risk of damage
- Crops sown in later spring or early summer are at greater risk

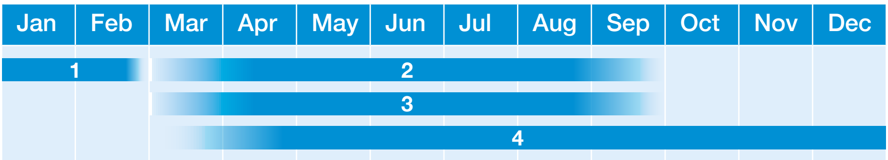
Life cycle, identification and symptoms

The adult is a small, greyish-black fly, 4–5 mm long.

The egg is white, elongated and about 1 mm long.

The larva is a white maggot, which reaches 5–8 mm in length.

The pupa is reddish-brown and about 5 mm long.



1. Bean seed flies overwinter as pupae in the soil.
2. Adults emerge and females lay eggs just below the soil surface – generally singly – and up to 40 eggs in one day. Typically, a period of several days elapses before a further batch of eggs is laid.
3. The larvae feed on the buried seed or the cotyledons of the seedling (prior to sprouting). In the absence of a suitable host plant, larvae feed on decomposing organic matter.
4. The larvae pupate in the soil at varying depths.

Bean seed flies can complete between three and six generations per year, depending on temperatures.

In all crops, damage mainly appears as patchy emergence or seedling death.

Severe attacks on runner beans or French beans can result in loss of the growing point. This causes seedlings to emerge in a twisted condition – known as 'snake head' – and die.

In onion, plants are often killed at the 'loop' or 'crook' stage.

The pest can cause hollowed grains in cereals.

Damage to newly transplanted cucurbits can occur within days of planting and cause complete plant collapse. Later attacks cause plants to wilt, especially during dry weather.

On asparagus, attacked spears are deformed. They often split and have a bitter taste.

Bean seed fly adult

Bean seed fly life stages

Management

Non-chemical control

The presence of organic matter in the soil is an important stimulus for egg laying. Burying organic debris from previous crops should reduce risk.

Natural enemies include generalist predators, such as certain species of beetle, spiders, insect-pathogenic fungi and parasitoids (beetles and wasps). Two species of *Aleochara* (rove beetle, see page 189), parasitise bean seed fly pupae and may also predate eggs and larvae. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Monitor adults throughout the season with sticky and water traps. Yellow, blue and white traps are all effective, but white and some blues may be most effective.

AHDB Pest Bulletin provides monitoring information for this pest.

Thresholds

There are no established thresholds.

Insecticide resistance

None known.

Beet leaf miner *Pegomya hyoscyami*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

Importance

The incidence of late beet leaf miner (also known as mangold fly) has increased in recent years. Control options are very limited. Extensive damage can affect the plant’s photosynthetic ability. In large numbers, beet leaf miner can almost completely defoliate whole plants.

Risk factors

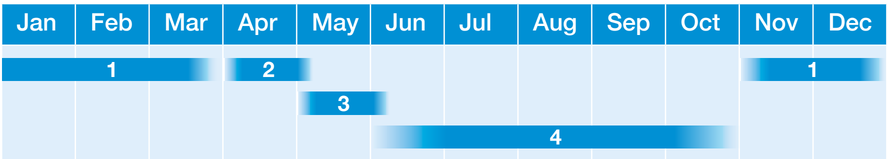
- The first generation is the most damaging, especially in late-sown crops with low leaf area. Although later generations can be numerous, damage is less serious because they inhabit outer leaves and often coincide with periods of rapid plant growth

Life cycle, identification and symptoms

The eggs are white, patterned and approximately 1 mm long.

Larvae are legless, translucent, whiteish-to-pale green and 6–8 mm long. Not easily visible, the appearance of mines and blisters on the beet leaf reveal their presence. Symptoms of heavy infestations can resemble those of bacterial leaf blight.

The pupae are brown, oval and approximately 5 mm long.



1. Overwinter in the soil as pupae.
2. Adults emerge throughout April. After mating, females lay eggs on the underside of beet leaves in groups of between two and ten.
3. Eggs hatch after 3–10 days. The larvae enter the leaf and feed between the two leaf layers. The mines join and blister as the larvae grow. After about 10–15 days, the fully grown larvae leave the leaf and fall to the ground, where they pupate.
4. There can be another one or two overlapping generations.

Management

Non-chemical control

The third generation is most susceptible to predation by natural enemies, such as parasitic flies (for example, *Opius nitidulator*). The decision of whether to make late applications of insecticide should balance the likelihood of success against the risk of harming these natural enemies. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Eggs can readily be seen with the naked eye on the underside of leaves. If mines are seen in the leaves, they should be checked to see if thresholds have been reached.

Because larvae are hard to control inside the leaf, the optimum spray timing is at egg hatch.

Thresholds

The threshold for treatment is when the number of eggs and larvae exceeds the square of the number of true leaves. For example, a plant with four true leaves would need a population of 16 (4 x 4) or more eggs and larvae to warrant treatment.

Insecticide resistance

None known.

Beet leaf miner larva

Bean leafminer damage

Bean leafminer damage

Brassica leaf miner *Scaptomyza flava*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Brassica leaf miner is a pest of major economic importance in vegetable brassicas. Damage to brassica salad crops, such as rocket and tatsoi, has been particularly severe.

In oilseed rape, it is unlikely these pests will ever justify insecticide treatment. In general, the pest only infests the first developing true leaves, which usually die during the winter. The cabbage leaf miner (*Phytomyza rufipes*) also affects this crop, limited to mining damage in the outer leaf petioles, which, once again, die during the winter.

Risk factors

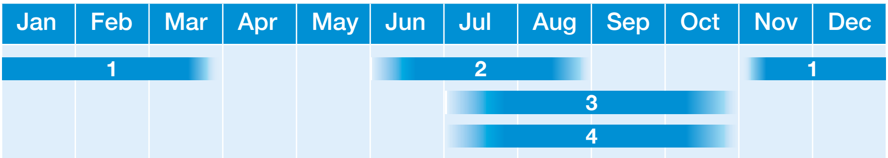
- Adults are generally most abundant in September

Life cycle, identification and symptoms

The adult is pale brown with faint stripes on the thorax and red eyes. The wings are about 50% longer than the head and thorax combined. It is about 3 mm long with a wingspan of 6 mm.

Eggs (0.3–0.4 mm long, 0.2 mm wide) are laid singly, although close together.

The larva is a cylindrical maggot, which becomes greenish and 0.4–5 mm long. Tpupa is brown and about 3 mm long.



1. Brassica leaf miner overwinters as pupae in the soil.
2. Adults are generally most abundant in September, although local peaks of activity can occur in July or August. Females can lay more than 300 eggs in punctures made within the lower surface of the leaf. The number of generations per year in the UK is unknown.
3. Hatching larvae feed between the upper and lower surfaces of the leaf. They move towards the midrib and create a long narrow mine that expands into a large, irregular white/yellow blotch. Several larvae may occupy the same mine. Typically, mines are visible between July and October.

In smaller leaves, the mine lies in the centre of the leaf and often touches the petiole. In larger leaves, the mine is to one side of the midrib. Frass (droppings) is usually deposited in green clumps near the margin of the mine.

4. Larvae usually drop to the ground to pupate, but sometimes a separate pupation leaf mine is used.

Brassica leafminer damage

Brassica leafminer damage

Management

Non-chemical control

Cover vegetable brassicas with insect-proof netting when the adult flies are active and laying eggs.

Monitoring

Yellow water traps or white sticky traps can be used to monitor adults. No forecasting systems have been developed.

Thresholds

None established.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

Brassica leaf miner life stages

Brassica pod midge *Dasineura brassicae*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

The brassica pod midge lays its eggs in the holes left by seed weevils in developing oilseed rape pods (see page 18). Larvae feed within the pod, causing swelling. Pods eventually burst. With damage greatest on headlands and affected pods very conspicuous, the effect of this pest on yield can be overrated. However, spring oilseed rape yields can be severely reduced.

Risk factors

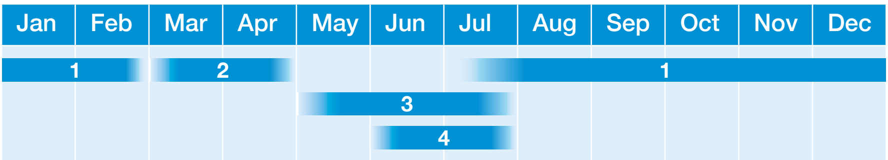
- The adult midge is a weak flyer, so crops on headlands are more exposed. Consequently, the largest yield losses often occur in small narrow fields
- Reduced risk in fields that are at least 0.5 km away from areas with hosts in the previous 1–2 years

Life cycle, identification and symptoms

Adult midges are small and dark orange.

Eggs are minute.

Mature larvae are white, 2 mm long, with no legs or distinct head.



1. Larvae overwinter in the soil.
2. Adults emerge.
3. Adults mate. Females fly to oilseed rape to locate cabbage seed weevil holes and damaged areas. Here, minute eggs are laid in clusters inside the pod.
4. Large numbers of larvae hatch and feed on the inner walls of the developing pods. Infested pods become yellow, deformed and split prematurely, leading to loss of seed. Larvae drop to the soil to form cocoons, sometimes leading to a second generation.

Management

Non-chemical control

Blocking oilseed rape fields and rotating the crop around the farm helps reduce the effect of immigrant pests.

Several wasp parasitoids, including *Omphale clypealis* and *Platygaster subuliformis*, may attack pod midge, killing up to 75% of larvae. Other natural enemies include spiders, ground beetles, rove beetles and predatory flies. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Monitor and control cabbage seed weevil – this is the most effective way of avoiding damage from the brassica pod midge.

Thresholds

Control of brassica pod midge is dependent on the control of cabbage seed weevil. Thresholds for cabbage seed weevil are one weevil per two plants in the north of the UK and one weevil per plant elsewhere (see page 18).

Insecticide resistance

None known.

Brassica pod midge larvae

Brassica pod midge symptoms

Brassica pod midge symptoms

Cabbage root fly *Delia radicum*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Present throughout the UK, cabbage root fly can damage cabbage, cauliflower, broccoli, Brussels sprout, kale, Chinese cabbage, swede, turnip and radish. Generally, it is a minor pest of oilseed rape.

If uncontrolled, the pest can infest large numbers of plants. Economic losses depend on the effect of damage on both plant growth and quality.

Plants with low levels of root damage usually survive, particularly if irrigated or if conditions are wet. However, since cabbage root fly damage can affect uniformity, an increased number of passes may be required at harvest (for example, for cauliflower).

In certain circumstances, cabbage root fly larvae may also infest broccoli florets, Brussels sprout buttons and the foliage of Chinese cabbage.

Risk factors

- Newly emerged crops and recently transplanted module-grown plants are at a greater risk. These lack the large root systems needed to tolerate moderate-to-high levels of infestation
- Control is particularly important in crops where the marketable part is damaged (for example, root crops, Brussels sprout buttons, broccoli florets, Chinese cabbage)
- In oilseed rape, crops that have emerged before the end of August are most at risk of attack

Adult cabbage root fly

Cabbage root fly damage

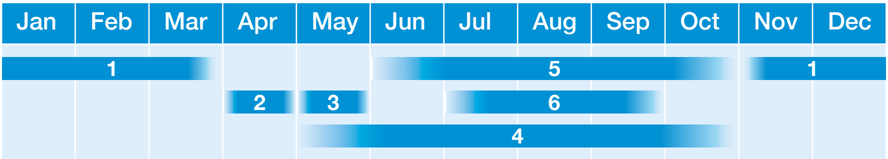
Life cycle, identification and symptoms

The adult flies are greyish-brown and resemble small houseflies. The male is 5–6 mm long and the female 6–7 mm.

The eggs are white and about 1 mm long.

The larvae are fairly transparent, tapering and legless with a reduced head. The mouthparts look like black hooks. Fully grown larvae are 5–8 mm long.

The pupae are dark brown and barrel-shaped, with smoothly rounded sides.



1. Pupae from late second and early third generations overwinter in soil.
2. Adult flies emerge and feed/mate.
3. Eggs are laid, mainly in the soil around the stems of brassica plants (first generation).
4. Larvae feed primarily on the roots of brassica plants, although they sometimes feed on the aerial parts. Plants may wilt or die. When mature, larvae drop to the soil to pupate.
5. Most pupae reside 8–12 cm below the soil surface.
6. Two to three overlapping generations occur. Adults emerging in August and September can infest oilseed rape.

Cabbage root fly adult

Cabbage root fly larvae

The life cycle is driven by temperature, and activity is earlier in warm years or locations. In the UK, there are generally two to three generations of adults in the South and only two generations in the North.

In some areas (for example, parts of Devon and southwest Lancashire), a proportion of cabbage root flies emerge later in the spring than would be expected. These are called ‘late-emerging’ flies and they are genetically different from ‘early emerging’ flies.

When plants have large root systems, damage may not be apparent until harvest. Even at this stage, damage to aerial parts may be difficult to identify.

Management

Non-chemical control

Fine mesh netting (crop covers) may prevent egg laying by female cabbage root flies on susceptible crops (such as swede). They can lay eggs on or through netting that touches the crop, but the incidence of this is low. Other physical and cultural approaches (companion planting, vertical fences and trap crops) are not as effective as insecticides or netting.

Natural enemies contribute to control. These include two parasitoids, spiders, ground and rove beetles, and predatory flies (Muscidae). Use the SAFE approach to encourage natural enemies – see pages 185–186.

To date, biological control with predators or parasitoids has not been commercially viable. There is evidence that the use of insect-pathogenic nematodes or insect-pathogenic fungi may be effective in certain situations.

There is no host–plant resistance available at present.

Cabbage root fly larva

Cabbage root flies killed by a fungus

Cabbage root fly damage on swede

Monitoring

Capture adult flies in yellow water traps or more specialised traps that release a semiochemical (related to the distinctive chemical compounds produced by brassica).

Sample the soil around plants to determine the presence of eggs.

Use weather-based forecasts to predict the time of egg laying.

AHDB Pest Bulletin provides monitoring and forecasting information for this pest.

Thresholds

None established. Larvae are very difficult to control, so prophylactic treatment is often necessary.

Insecticide resistance

None known.

Carrot fly *Psila rosae*

Crops affected

Alliums	**Carrots**	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Carrot fly is present throughout the UK. The larvae feed on the roots of carrot and other susceptible crops, making tunnels (mines) as they grow. When carrots are small, the plants can die. Larger plants can become unmarketable by the presence of a few relatively superficial mines. Damage may not become apparent until harvest.

Risk factors

- As carrot fly adults do not disperse over great distances, closer proximity to fields previously infested with carrot fly increases risk
- Damage is likely to be greatest at the edges of fields

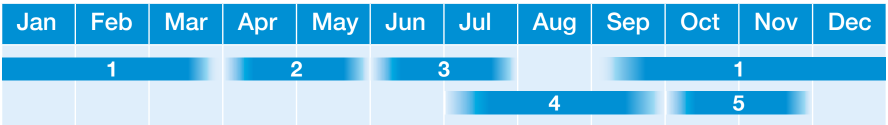
Life cycle, identification and symptoms

Adults are 6–8 mm long, with a black shiny body, reddish-brown head and yellow legs.

The white-coloured eggs are elongate (0.2 mm diameter, 0.6–0.7 mm long).

The larvae are creamy white and 8–10 mm long when mature.

Pupae are brown, about 5 mm long and 1.5 mm in diameter.



1. Carrot flies overwinter as pupae or as larvae. Larvae feed on overwintered crops and pupate in spring.
2. The first generation of adult flies emerges in April and May, with most eggs laid during May.
3. Larvae feed on the lateral roots of carrots and then burrow into the taproot as it develops. When mature, larvae pupate.
4. Adults emerge from mid-July onwards to produce the overwintering generation.
5. In warm locations, a third generation of adults may emerge in October and November. The progeny of these flies are unlikely to develop sufficiently to cause further damage before the winter.

Management

Non-chemical control

Crop rotation and the separation of susceptible crops from sources of carrot fly are important. Where feasible, suppress populations by delaying sowing until after the first generation flies have laid most of their eggs.

Fine mesh netting (crop covers) prevents egg laying. Other physical and cultural approaches (companion planting, vertical fences and trap crops) are not as effective as other approaches.

To date, biological control with predators or parasitoids has not been commercially viable. There is evidence that the use of insect-pathogenic nematodes may be effective in certain situations. Some cultivars are less susceptible to carrot fly damage, but none has complete resistance.

Monitoring

Use yellow or orange sticky traps to monitor adults. Orientating the traps at an angle of 45° to the vertical improves selectivity for carrot flies, which land on the lower surface.

Use weather-based forecasts to predict the timing of egg laying.

AHDB Pest Bulletin provides monitoring and forecasting information for this pest.

Thresholds

None established.

Insecticide resistance

None known.

Carrot fly adult

Carrot fly damage

Frit fly *Oscinella frit*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Frit fly is usually most damaging to cereals sown after grass and spring-sown oats. There are three generations of frit fly per year. The first generation is damaging to winter cereals, grasses, maize and late-sown spring oats. From late July, the second generation of adults lays eggs on oat husks, which can lead to serious damage to the ears of spring oats. The third generation lays eggs on grasses and winter cereals.

Risk factors

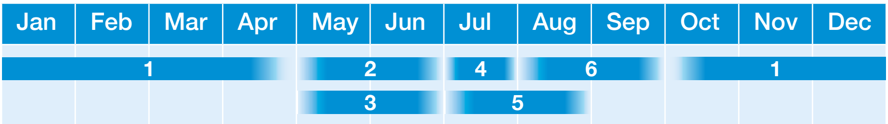
- Cereals sown after grass leys and spring oats are at highest risk of damage
- Crops are most susceptible to damage up to the four-leaf stage. Warm temperatures during this time increase the risk of infestation
- Sowing spring oat crops early or choosing crops that develop rapidly can narrow the period of risk

Life cycle, identification and symptoms

Adults are small (about 1.5 mm long), shiny and black and are active in warm, dry conditions.

Larvae are small, white maggots, about 3 mm long when mature.

Pupae are protected by a reddish-brown casing.



Adult frit fly

1. Larvae feed in shoots of cereals and grasses and pupate within the plants.
2. First generation adults emerge and lay eggs on grasses, spring cereals and maize.
3. Larvae feed within infested plants and pupate.
4. Second generation adults emerge and lay eggs beneath oat husks and grasses.
5. Larvae feed on oat kernels or grasses.
6. Third generation adults lay eggs on grasses in stubble and early winter cereals.

Damage occurs across the year and can affect shoots and grain. This is in contrast to wheat bulb fly and yellow cereal fly symptoms, which are generally only seen from early spring.

Damage in cereals is most evident as 'deadhearts', whereby the central leaf turns yellow, withers and dies – often falling out completely. This can kill very young plants. Older plants can produce several tillers following the death of the main shoot. If these are invaded, the shoots are weakened, resulting in reduced yield and later-ripening grain. In oats, deadhearts can be mistaken for stem nematode damage (see page 162).

Spring oats damage may occur prior to ear emergence and lead to blind, withered spikelets. Damage to oat ears is difficult to detect and the blackened, thinned kernels can only be seen by opening the grains. In maize, severe damage shows as ragged leaves, often torn into strips. Mild damage is evident as neat rows of holes across leaves.

Frit fly larvae

Frit fly damage

Management

Non-chemical control

Later sowing of winter cereals can reduce risk from the third generation of frit fly. Grass leys should be ploughed at least 4 weeks prior to sowing. For spring oats, early sowing reduces the risk of the vulnerable stage of the crop coinciding with egg laying. Encouraging rapid establishment and growth (for example, through rolling) will help to minimise damage.

Natural enemies include spiders, ground beetles, rove beetles, predatory flies and many parasitoid species. Use the SAFE approach to encourage natural enemies, see pages 185–186.

Monitoring

To assess pre-drilling risk in winter cereals, sample grass or stubble for frit fly eggs or larvae before ploughing. However, the main monitoring period is after full emergence (see Thresholds). AHDB Pest Bulletin provides monitoring and forecasting information for this pest.

Thresholds

If more than 10% of plants are damaged before the four-leaf stage, the crop is at risk.

Insecticide resistance

None known.

Gout fly *Chlorops pumilionis*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Gout fly is present across the UK. It is an occasional minor pest of wheat, barley and triticale.

In autumn-sown crops, yield losses range from 0.25 t/ha to total crop failure. Winter damage kills affected tillers and any tillers still dependent on the mother plant. At lower levels of incidence, unaffected tillers with developed crown root systems can compensate for damage.

On average, shoots damaged by spring generations of gout fly lose 30% of grain yield, but this can rise to 50% in late-sown spring crops.

Risk factors

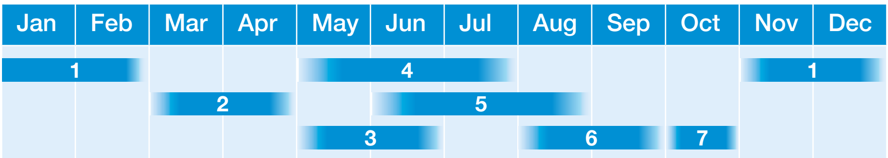
- Crops emerged by the end of September are at greatest risk from the autumn generation of flies
- Late-sown winter and spring crops are at greatest risk from the spring generation of flies. Crops at, or beyond, growth stage 37 by mid-May in southern England, or late May in the Midlands, usually suffer only minor damage
- Oats and maize are not affected

Life cycle, identification and symptoms

Adult flies are yellow with black markings and 4–5 mm long.

Eggs are minute, creamy white and torpedo-shaped.

Larvae are legless, translucent white and lack a distinct head. When fully grown, they are yellowish-white and 5.0–6.5 mm long, after which they form a somewhat flattened, brownish pupa.



1. Larvae overwinter in the centre of the plant, close to the root.
2. Larvae pupate.
3. Adult flies emerge and lay eggs on leaves close to the central shoots – usually one per shoot.

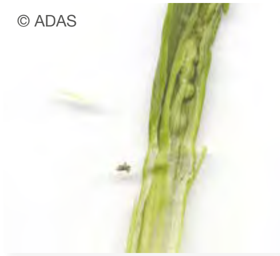
4. Hatching larvae burrow into the centre of the shoot.
5. Larvae pupate.
6. Adult flies emerge and lay eggs on early sown winter cereals, weed grasses and volunteer cereals in stubble. Eggs hatch in 7–10 days.
7. If conditions are mild, adults may remain active.

In autumn-sown crops, damage is visible as swollen, gouty and short tillers. This can kill the plant or result in other tillers producing weak ears in summer.

In spring-sown cereals, if the attack occurs before stem elongation, the tiller will be stunted, swollen and gouty and never produce an ear. If the plant is more developed, damage will be less severe; a poorly developed ear emerges with immature grains spoiled on one side, resulting in yield being halved.

Adult gout fly

Gout fly larva in spring barley



Bean leafminer damage

Gout fly eggs

Management

Non-chemical control

Sow winter wheat and winter barley after late September, if in sheltered fields near woodland. Sow spring crops as early as practical in high-risk areas.

Natural enemies include several parasitoid species. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Look for gout fly near woodlands and hedgerows.

Check plants for the presence of eggs at growth stage 12.

Thresholds

Treatment of winter crops may be beneficial when more than half of plants at growth stage 12 have eggs.

There is no threshold for spring-sown crops.

Insecticide resistance

None known.

Leatherjackets *Tipula paludosa* and *Tipula oleracea*

Crops affected

Alliums	**Carrots**	**Cereals**	**Field beans**	**Lettuce**
Oilseeds	**Peas**	**Potatoes**	**Sugar beet**	**Vegetable brassicas**

Importance

Leatherjackets are the larvae of crane flies ('daddy longlegs'), which mainly feed on roots and the underground parts of the stem.

Risk factors

- Crops following a grass rotation are at high risk. Larvae continue feeding in ploughed-down turf, moving on to feed on the new crop when the turf rots away. This leads to damage suddenly appearing weeks after crops emerge
- Cereal crops are less likely to suffer economic damage once they have tillered
- Winter cereals, particularly late-sown ones, may be attacked when soil temperatures are above 0.5°C
- Spring-sown crops are most vulnerable in April and May when the leatherjackets are large and voracious
- Prolonged damp conditions in late summer and early autumn increases leatherjacket numbers
- Dry September weather can considerably reduce numbers because eggs and young leatherjackets are vulnerable to desiccation

Life cycle, identification and symptoms

The larvae (leatherjackets) are greyish-black and grow to 40 mm in length. They have a tough skin and are plump and soft.

The adults (crane flies) have a long body (approximately 25 mm in length), long gangly legs and narrow wings.

1. Adults emerge and lay eggs.
2. Eggs hatch.
3. Larvae feed when soil is above 0.5°C.
4. Main larval feeding period.
5. Larvae pupate near soil surface.
6. Pupae.

Leatherjackets usually feed just below the soil on roots and stems. However, on warm, damp nights they may feed on the surface, making ragged holes in leaves and cutting off stems like cutworms.

Adult crane fly

Management

Non-chemical control

Cultivations decrease populations of this pest. Ploughing in July and early August (before the main egg-laying period) and covering the old sward well with soil can limit attacks. However, this could increase the risk of wheat bulb fly (see page 122). If ploughing occurs later, thorough consolidation and a good tilth can enable a crop to grow away and minimise the vulnerable period.

The larvae of the main pest species, *Tipula paludosa*, stop feeding by mid-June, so establishing crops, particularly vegetable brassicas, later than this can avoid damage to seedlings.

Leatherjackets (crane fly larvae)

Monitoring

Assess leatherjacket numbers before ploughing. Use a 10-cm diameter soil corer. Take 20 cores for areas of up to 4 ha. Soil is washed and sieved in a laboratory to extract the leatherjackets. Alternatively, a Blasdale apparatus can be used, which drives leatherjackets into trays of water by heating the soil cores from above.

An alternative method is to drive plastic pipes (30 x 10 cm) into the ground (by 5 cm) and fill them near to the brim with brine. Any leatherjackets will float to the surface. This method is less effective in recently cultivated soil because pipes are less effective at retaining brine. Proprietary brine-based testing kits are available.

Thresholds

Spring cereals: 50 leatherjackets/m^2, or five in 12 pipes, or 5/m of row.

Oilseeds: >50 leatherjackets/m^2, or more than five in 12 pipes, or greater than 5/m of row.

Insecticide resistance

None known.

Onion fly *Delia antiqua*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Onion fly is a highly localised pest in the UK.

Onion seedlings attacked by onion fly larvae quickly collapse and die. Larger plants are rendered unmarketable by the damage caused by larval feeding.

Risk factors

- Using implements that damage onion plants can increase the likelihood of infestation

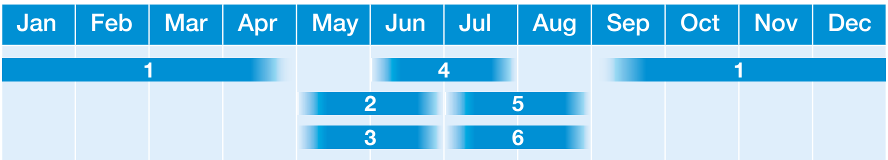
Life cycle, identification and symptoms

Adult flies are pale grey, hairy and 5–7 mm long.

The eggs are elongate (1 mm long) and white. Females may lay 100–500 eggs during their lifetime.

The larvae are white maggots that reach 9–10 mm in length.

The pupae are oval, reddish-brown to dark brown and 6–7 mm long.



1. Overwinter as pupae in the soil.
2. The first generation of flies emerges in May/June. The first eggs are usually laid in batches towards the end of May in soil adjacent to host plants or in leaf sheaths.
3. Larvae burrow into the bases of plants, where they feed on soft tissue
4. Pupation occurs in the soil near to the host plant.
5. The second generation of flies emerges in July/August.
6. Second generation of larvae.

There are usually two generations per year, but, in warm locations, there may be a partial third generation.

Onion fly maggots present in large numbers can lead to patchy crops. Older plants wilt and the foliage may discolour, dry out or start to decompose.

Larger bulb onions withstand attacks, but, eventually, the foliage dies. When bulbs are cut open, larval feeding damage is evident.

Onion fly life stages

Onion fly damage

Onion fly damage

Management

Non-chemical control

Onion fly is a highly localised pest and crop rotation may be an effective way of reducing the risk.

Natural controls are likely to include generalist predators, such as certain species of beetle, insect-pathogenic fungi and parasitoids (beetles and wasps). Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Use white, blue or yellow water or sticky traps to monitor onion fly adults. Trap captures indicate when onion flies are active and how numbers change during the season.

Thresholds

None established.

Insecticide resistance

None confirmed in UK; however, insecticide resistance is present in North American populations.

Orange wheat blossom midge *Sitodiplosis mosellana*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Orange wheat blossom midge larvae feed on developing seeds, causing small, shrivelled grains with poor germination. Damage to the outer layer of the grain (pericarp) allows water to enter. This results in sprouting in the ear and facilitates secondary attack by fungi. This affects both the yield and quality of grain harvested.

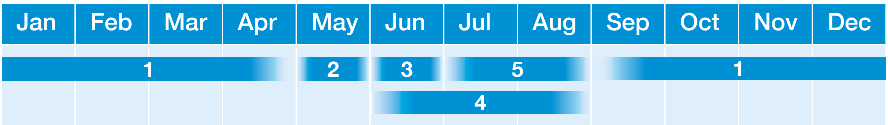
Risk factors

- Susceptible crops are vulnerable between ear emergence and flowering (growth stages 53–59)
- Cereals grown in any field in which wheat has been grown over the past 4 years has increased risk
- Larvae pupate in warm, moist soil, usually after heavy rainfall. Midges usually fly when the air temperature exceeds 15°C. On mild, sunny days, they fly later in the evening

Life cycle, identification and symptoms

Adult midges are orange and about 3 mm long. Males have long, feathery antennae. Females have a short ovipositor and lay cylindrical eggs.

Larvae are orange and up to 3 mm long.



1. Larvae overwinter in a cocoon in the soil, where they can survive for 10 years or more. They pose a major threat for up to 4 years.
2. If the soil is warm (>13°C) and moist, larvae move to the surface to pupate. If not, a proportion will remain in the cocoon stage.
3. Adults emerge, resting at the crop base during the day and laying eggs in the florets from dusk.
4. Eggs hatch within 4–10 days and larvae feed on the developing grain. Larvae that hatch after flowering do not develop properly and cause little damage.
5. Larvae feed on developing grain for about 2 weeks, then drop to the ground and burrow into the soil.

Management

Non-chemical control

Resistant wheat varieties are available. Reducing the frequency of wheat crops in the rotation can help reduce midge populations.

Natural enemies include generalist predators and small parasitic wasps, especially *Macroglens penetrans*, which parasitises the eggs. The parasitoid larvae develop on the midge larva once it has overwintered. As a result, crop damage is not reduced immediately; however, parasitism levels can exceed 80%. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Adult orange wheat blossom midge

Monitoring

Pheromone traps provide the earliest warning of activity. Place two traps in fields with damaging levels of midges in the past 2 years, even if the current crop is not a cereal. Prioritise monitoring near or in susceptible milling wheat and seed crops. Set traps at crop height at growth stage 45, 1 week before ear emergence until flowering (growth stage 61). Hang yellow sticky traps at ear height at the start of ear emergence. The presence of midges in spider webs is also a good indication of activity.

Monitoring for egg laying during ear emergence is best done on warm, still evenings. Part the crop and count the number of midges.

Orange wheat blossom midge larvae

Thresholds

Pheromone traps

Thirty or more midges: general risk in the next week. Monitor crops for females.

More than 120 midges: very high risk. Treat nearby wheat crops at growth stages 53–59, as soon as possible.

Yellow sticky traps

Ten midges per trap indicates a risk to the crop.

Visual crop inspection

For feed crops: one midge per three ears.

For milling and seed crops: one midge per six ears.

Insecticide resistance

None known.

Pea midge Contarinia pisi

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	**Peas**	Potatoes	Sugar beet	Vegetable brassicas

Importance

Pea midge attacks can result in very serious yield losses, especially when populations build up in intensive pea-growing areas.

Risk factors

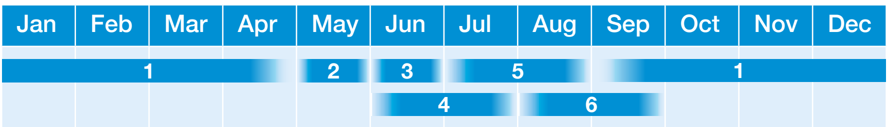
- Increased risk in areas where peas have been grown previously
- Vining peas can be more susceptible than combining peas
- Crops are most susceptible at the early green-bud stage
- From the Humber northwards, vining peas may not be attacked until late June, so early crops may escape serious damage

Life cycle, identification and symptoms

The adults are gnat-like flies with a yellow-grey body. They are about 2 mm long with long legs. The head is dark, with very fine antennae. The semi-transparent wings are slightly longer than the body and folded together along its back, when at rest.

The eggs are approximately 0.3 mm long, oval with a tail-like tip and have a translucent, jelly-like appearance.

Larvae are dirty white and 2–3 mm long when mature.



1. Larvae overwinter in soil in cocoons.
2. Larvae pupate. Some may remain in the soil for 1 year or more.
3. First-generation adults emerge and lay eggs in batches on the rudimentary buds and leaves surrounding them. Hatching larvae enter buds to feed. They may also feed in the clustered leaves of the terminal shoot and the pods.
4. First-generation larvae drop into the soil. Some pupate to create a second generation, while others remain to overwinter.
5. Second-generation adults emerge and lay eggs on the crop. Hatching larvae enter buds to feed.
6. Second-generation larvae drop into the soil to overwinter.

Infested buds become swollen, gouty and do not produce pods, thus reducing yield. Leading shoots may also become deformed, limiting their extension growth and producing a 'cabbage' or 'nettle-head' appearance. In wet periods, damaged tissue may also provide a site for infection by fungi such as *Botrytis* spp.

Pea midge adult

Management

Non-chemical control

Cultural controls include early spring sowing, the selection of early varieties, crop rotation and deep ploughing to bury the overwintering larvae. Avoid sowing peas on land adjoining previously infested land.

The bright red larvae of the midge *Lestodiplosis pisi* prey on pea midge larvae. Several parasitoids have also been identified. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Pea midge larvae

Monitoring

A pheromone monitoring system is available comprising four sticky traps with pheromone lures. Place traps 10 m apart in the previous year's pea field by the third week of May to monitor adult emergence from overwintering sites. Inspect traps at least twice weekly and replace the sticky cards each time.

Thresholds

If more than 500 midges are caught on one trap, nearby susceptible pea crops should be examined (as late in the day as possible) for the pest.

Pea midge damage

Insecticide resistance

None known.

Saddle gall midge *Haplodiplosis marginata*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Saddle gall midge is a sporadic pest of cereals, which usually persists at low population levels. Outbreaks tend to be associated with continuous cropping or tight cereal rotations.

Constriction of the vascular supply to the ears and lodging of gall-weakened stems causes yield loss.

Risk factors

- Large populations are associated with heavy soils
- Crops are most susceptible to attack between growth stages 31 and 39
- Warm and damp soil conditions in May/June are ideal for large numbers of adults to emerge
- Late-sown winter wheat and winter barley and spring-sown cereal crops are at greatest risk
- Oats attract adults for egg laying but are rarely damaged
- Continuous cereals increase the risk of soil populations building up over time
- From the Humber northwards, vining peas may not be attacked until late June, so early crops may escape serious damage

Adult saddle gall midge

Life cycle, identification and symptoms

Adult midges are up to 5 mm long, red with a black head and long legs.

Eggs are 0.5 mm in length, orange-red and elongated.

Hatching larvae are small and whitish-green. As they mature, they turn orange-red, reaching 0.4 mm in length.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		2		3		5			1		
					4						

1. Larvae overwinter in soil.
2. Larvae pupate, if conditions are suitable, and can remain in the soil for several years.
3. Adults emerge and lay eggs in a chain or raft-like pattern along the veins of cereal and grass leaves.
4. Hatching larvae move down the leaf to feed on the stem underneath the leaf sheath, causing a distinctive saddle-shaped depression.
5. Mature larvae fall off the plant, into the soil to overwinter.

Gall formation usually occurs on the top three internodes, often hidden beneath the leaf sheath. Galls can restrict nutrient supply to the ear, act as a site of secondary infection and weaken the stem, particularly if numerous galls fuse together.

Management

Non-chemical control

Non-cereal or oat break crops in the rotation will allow population levels to decline. Early sowing (in September) can also reduce the risk of damage.

Carabid beetles, staphylinid beetles and spiders may give some control by preying on larvae in the soil. Some evidence of control by parasitoids has been recorded in Germany. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Use pheromone, yellow water or sticky traps to monitor for adult midges.

Take regular soil samples and extract the larval and pupal stages by wet sieving to monitor midge development in soil.

Thresholds

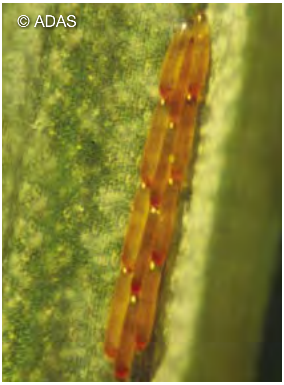
None established.

Insecticide resistance

None known.

Saddle-shaped galls on wheat under the leaf sheath

Saddle gall midge larvae



Saddle gall midge eggs

Swede midge *Contarinia nasturtii*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Swede midge attacks many types of brassica and leads to loss of yield and quality. It is a sporadic pest in the UK.

Risk factors

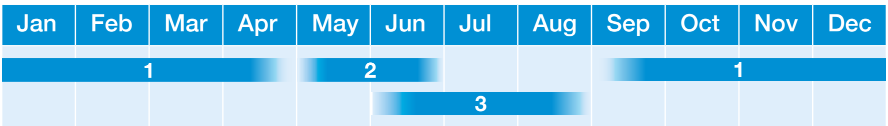
- Continuous production of a host crop allows swede midge populations to build up very quickly
- Outbreaks may occur more frequently in years of high humidity and temperature

Life cycle, identification and symptoms

The adult is a tiny, greenish-yellow-to-light brown fly (1.5–2 mm) with hairy wings. It looks similar to closely related midge species.

The egg is very small (0.3 mm), initially transparent, turning creamy white as it develops.

The larva is a small maggot, initially 0.3 mm in size and reaching a final size of 3–4 mm. Larvae are initially translucent, becoming increasingly yellow until lemon-yellow at maturity.



1. The larvae of the third generation overwinter in the soil.
2. These larvae pupate in spring and adults emerge from the soil.
3. Each female lays batches of 15–20 eggs on the younger parts of the plant, particularly the terminal bud. The larvae feed mostly on the growing point, but can live on almost any part of the plant. When fully grown, the larvae move to the ground, form cocoons in the soil and pupate near to the soil surface.

There are usually three generations in a year. During periods of drought, the larvae may enter a period of dormancy, but development resumes after rainfall.

Damage symptoms include swollen flowers, scarring in the growing point and on leaf petioles and flower stalks, blindness and crinkled leaves. The main shoot is often killed, causing the side shoots to grow out forming a many-necked plant.

Management

Non-chemical control

Annual crop rotation is the most effective way to reduce swede midge populations.

Crop covers might exclude swede midge, provided the mesh size is sufficiently small.

Monitoring

Pheromone traps are available; however, knowledge of insect identification and a microscope are required to separate the male swede midges from other species of fly that accidentally enter the traps.

Thresholds

None known.

Insecticide resistance

None known.

Adult swede midge on a sticky trap

Damage caused by swede midge larvae

Turnip sawfly *Athalia rosae*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

The turnip sawfly, also known as cabbage leaf sawfly, is a sporadic pest of brassicas. In 2006, a major outbreak caused significant crop damage in southern England.

Risk factors

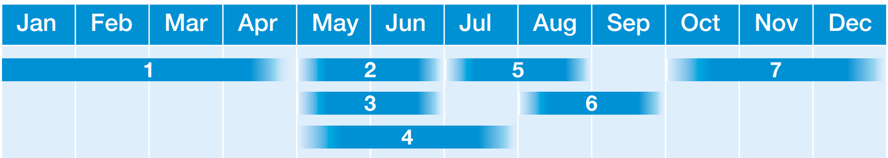
- Warm conditions (>18°C) increase the risk of adult activity
- Favourable winds increase the possibility of mass immigrations from mainland Europe, posing a risk to southern counties
- A third generation may occur after hot summers, which can coincide with the early stages of crop emergence of oilseed rape
- Slow-emerging crops are at increased risk of significant defoliation
- Close proximity to overwintering sites increases the risk to spring-sown crops

Adult turnip sawfly

Life cycle, identification and symptoms

The adults are around 7–8 mm in length. The abdomen is entirely orange, while the thorax is orange with two black ‘shoulder pads’ (other similar sawflies have an entirely black upper surface to the thorax). Legs are orange with black bands.

The caterpillar-like larvae are greenish-black with a paler stripe along the side of the body. They have a shiny black head and can grow to 18 mm long.



1. Pupae overwinter in soil.
2. First generation of adults emerges and lays up to 300 eggs in the margins of host leaves.

3. Eggs hatch in 6–8 days. Larvae initially feed inside the leaf then externally on the underside of the leaf, which can become skeletonised.
4. At maturity, the larvae drop to the soil to pupate.
5. Second generation of adults emerges and lays eggs.
6. Third generation of adults emerges and lays eggs.
7. Pupae overwinter in soil.

Turnip sawfly larvae

Turnip sawfly larvae

Turnip sawfly larvae and damage

Management

Non-chemical control

Situate spring-sown crops away from known overwintering sites (such as autumn-sown oilseed rape), wherever possible.

Protect high-value, sensitive crops from adults with covers, such as insect-proof mesh.

Turnip sawflies are hosts for parasitic wasps and flies. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Monitoring

Adult sawflies feed on pollen and nectar. Their presence in flowering hedgerows can give an early warning of imminent attack.

Use yellow sticky traps and water traps to monitor adult activity in May until September.

Inspect crops for turnip sawfly larvae on damaged leaves or close to damaged plants.

Thresholds

Oilseed rape

One to two larvae per plant.

Please note that this is a German threshold and little information is available on its validity under UK conditions; it is therefore offered for guidance only.

Insecticide resistance

None known.

Wheat bulb fly *Delia coarctata*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Wheat bulb fly is one of the most serious pests of wheat in the east of the UK, although it is not abundant every year.

Yield loss depends on tiller density at the time of attack. Crops with a single shoot in February are most vulnerable and may die. However, a well-tillered crop can tolerate many larvae (up to 100 larvae/m^2).

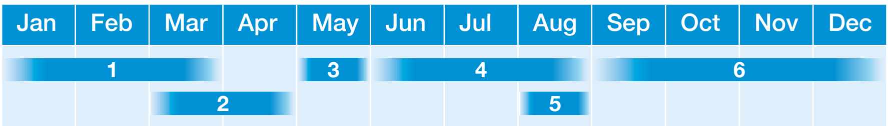
Risk factors

- Late-sown (November onwards) winter cereals and early sown (before April) spring cereals are at increased risk
- Oats are not attacked
- Bare, especially freshly cultivated, soil during egg laying is at higher risk
- Eggs laying also occurs between row crops, such as potatoes, sugar beet, celery and onions – especially if the foliage is wilting under hot, dry conditions

Life cycle, identification and symptoms

Adults look similar to house flies, although they are slightly smaller.

Hatching larvae are legless, white, without a distinct head and are pointed at the front end and blunt at the rear end.



1. Larvae hatch and invade roots of wheat, barley and rye, boring into the plant at the base of the stem to feed.
2. Larvae attack three to five further shoots and cause 'deadheart' symptoms, which may be difficult to detect before March. The point of entry shows as a ragged hole.
3. Larvae pupate in the soil at base of plants.
4. Adult flies emerge and feed on saprophytic fungi on host plant.
5. Eggs laid on bare soil and between row crops.
6. Overwinter as eggs.

Management

Non-chemical control

Ground beetles and their larvae are the main predators of wheat bulb fly eggs. Wheat bulb fly larvae may be parasitised by small rove beetles, particularly *Aleochara bipustulata*, with up to 50% killed. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Avoid bare ground in July/August prior to drilling cereals and delay cultivation until after egg laying. On bare fallows, a crop of mustard sown to cover the soil by mid-July will also reduce egg laying.

Sowing early can help reduce risk, as tillering will have started tiller before eggs hatch, increasing crop tolerance. An increased seed rate can help compensate for attack, particularly in late-sown crops.

Adult wheat bulb fly

Wheat bulb fly larva

Deadheart symptoms

Monitoring

Estimate egg numbers and the timing of egg hatch from soil samples. The AHDB wheat bulb fly survey provides a regional indication of risk. It uses soil samples, taken each September, from 30 fields prone to attack (split equally across eastern and northern England) and calculates the number of wheat bulb fly eggs/m^2.

When deadheart symptoms show, examine plant samples to determine the number of larvae.

Thresholds

Crops sown before November are unlikely to benefit from seed treatment.

A seed treatment may be necessary in all other instances, except where there are fewer than 100 eggs/m^2 in crops drilled between November and December. The risk, however, increases with later the drilling and higher the egg count.

Insecticide resistance

None known.

Yellow cereal fly *Opomyza florum*

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Each yellow cereal fly larva damages only a single shoot, so economic impact is generally low. Most crops can withstand a considerable number of larvae by producing more tillers.

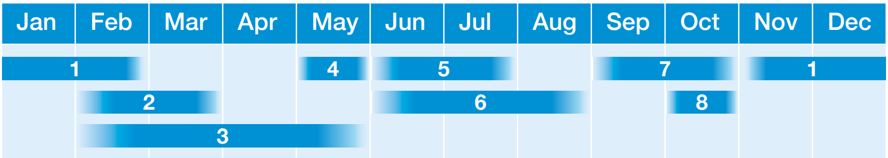
Risk factors

- Early sown crops in sheltered fields close to woodland are at increased risk
- Increased risk to crops with low plant populations

Life cycle, identification and symptoms

The adult fly is small (5.0–5.5 mm long) with an orange-brown body and black wing markings.

The larvae are yellow with pointed ends. They are thinner than wheat bulb fly larvae and similar to frit fly larvae (though occurring later in the winter).



1. Eggs overwinter.
2. Eggs hatch.
3. Larvae enter and feed on wheat shoots, resulting in classic ‘deadheart’ damage, whereby the central shoot becomes yellow and dies. The point of entry shows as a clean, brown line encircling or spiralling around the shoot (in contrast to the ragged hole left by wheat bulb fly).
4. Larvae pupate in the shoot or soil.
5. Adult flies hatch.
6. Adults spend the summer in woodland.
7. Flies move to early sown wheat crops.
8. Eggs are laid on the soil at the base of host plants.

Symptoms are similar to frit fly damage (see page 104), particularly in winter wheat, but are not noticeable until spring. Yellow cereal fly and wheat bulb fly larvae both feed in crops at the same time of year.

Yellow cereal fly adult

Management

Non-chemical control

Ground beetles feed on soilborne eggs and pupae. Ladybirds and soldier beetles feed on pupae. Use the SAFE approach to encourage natural enemies – see pages 185–186.

It should be possible to avoid economic damage by planting at least 200 plants/m^2 in vulnerable situations.

Yellow cereal fly larva

Monitoring

Plant dissection can determine the level of pest infestation. However, as the economic effect of yellow cereal fly is generally low, it is rarely worth monitoring.

Thresholds

None established.

Insecticide resistance

None known.

Entrance hole

Minor and/or emerging pests

Allium leaf miner (*Phytomyza gymnostoma*)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

First detected in the UK in 2002, the allium leaf miner has since spread, particularly in the Midlands. Initially a pest of allotments and gardens, it now damages commercial crops of onion, leek and garlic.

In the UK, it probably has two generations per year: the first generation lays eggs in March/April, while the second generation lays eggs in October/November.

Before laying eggs on the stems or bases of leaves, the female flies puncture leaves and suck up the exuding sap. This causes distinctive lines of white dots on the foliage. The larvae make tunnels in the foliage, stems and bulbs. Pupation takes place mainly within the stems and bulbs, but some pupae may end up in the soil, especially where plants have rotted off.

Plants affected by allium leaf miner tend to rot because of secondary infections from fungi and bacteria that develop in the damaged tissues.

Protect plants with insect-proof netting at times when the adult flies are active and laying eggs.

Allium leaf miner damage

Allium leaf miner damage

Cereal stem sawfly (*Cephus pygmaeus*) **and leaf sawflies**

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

The cereal stem sawfly is usually a minor pest. However, crop losses occur when there are large numbers. The pest usually attacks winter wheat, but can also damage spring wheat and barley.

Several species of leaf sawfly also attack cereals. Although this can cause damage in early summer, it is rarely economically important.

Several parasitoid species attack cereal sawflies at all life stages.

Cereal stem sawfly adult

Yellow wheat blossom midge (*Contarinia tritici*)

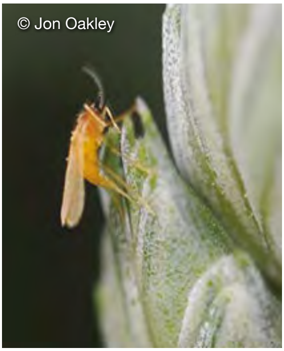
Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Yellow (or lemon) wheat blossom midge is less common than orange wheat blossom midge and is rarely damaging. It follows a similar life cycle, but is less persistent, with larvae pupating within 3 years of entering the soil. Adults emerge at a similar time to orange wheat blossom midge, but lay eggs slightly earlier (as the boot splits to reveal the ear).

The larvae feed on the stigma, preventing pollination and development of the grain and the anthers, which are retained within the floret. After 2–3 weeks of feeding, they jump from the floret in wet weather. Some larvae pupate in September, forming a partial second generation that feeds on couch grass.

Varieties with resistance to orange wheat blossom midge are not resistant to yellow wheat blossom midge.



Yellow wheat blossom midge adult

Pests: Moths and butterflies

131 An introduction to moths and butterflies

132 Cabbage moth (*Mamestra brassicae*)

134 Cutworms/noctuid moths (e.g. *Agrotis segetum*)

136 Diamond-back moth (*Plutella xylostella*)

138 Garden pebble moth (*Evergestis forficalis*)

140 Large white butterfly (*Pieris brassicae*)

142 Leek moth (*Acrolepiopsis assectella*)

144 Pea moth (*Cydia nigricana*)

146 Silver Y moth (*Autographa gamma*)

148 Small white butterfly (*Pieris rapae*)

150 Swift moths (*Hepialus humuli* and *Korscheltellus lupulinus*)

152 Minor/emerging pests

152 Flax tortrix moth (Cnephasia asseclana)

An introduction to moths and butterflies

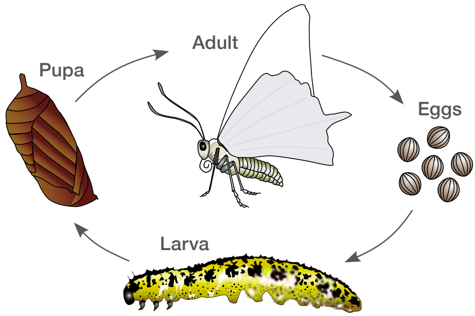
Butterflies and moths (Lepidoptera) are an important part of the ecosystem. However, the caterpillars (larvae) of some species are pests.

Life cycle

As male and female moths usually find each other by scent, pheromone traps can be used to monitor them. For butterflies, the initial attraction is by sight.

The outer skin of the caterpillar cannot grow. It is shed in a series of moults as the larva grows. When the caterpillar is fully grown, it turns into a pupa or chrysalis. This is a non-feeding stage; inside the chrysalis, the larval body is broken down and reassembled in the adult form.

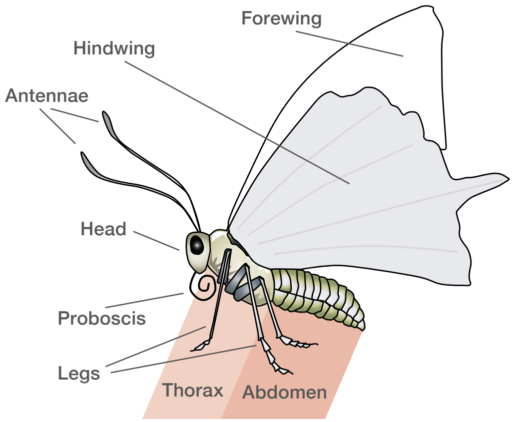
Defining features

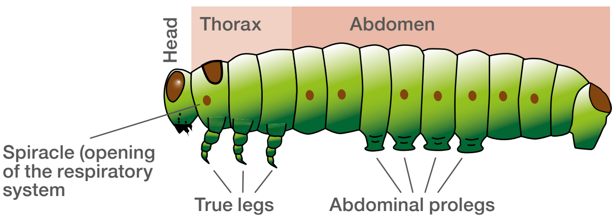


Butterflies and moths are distinguished from other insects primarily by the presence of scales on the external parts of the body, particularly the wings.

Caterpillars have a toughened head capsule and a soft, segmented body with three pairs of true legs and up to five pairs of abdominal prolegs.

See page 89 for a comparison of sawfly larvae and butterfly/moth caterpillars.





Cabbage moth *Mamestra brassicae*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Feeding by cabbage moth larvae can rapidly skeletonise the outer leaves of large plants and destroy small plants. Large larvae may bore into the hearts of some plants, such as heading cabbage. Frass (droppings), and the larvae themselves, can contaminate fresh produce.

Cabbage moth eggs

Risk factors

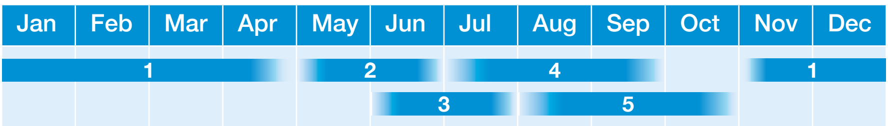
- Vegetable brassicas are the most susceptible. Larvae also feed on a variety of plant species, including potato and other vegetables, without causing economic damage

Life cycle, identification and symptoms

Adults are greyish-brown, mottled with dark brown. The forewings have a span of 35–50 mm. There is a kidney-shaped marking with a white outline on each forewing and an irregular white transverse line near the wing margin.

Eggs are hemispherical (0.5–0.6 mm diameter) and white, darkening close to hatching.

Newly hatched larvae are green, ranging from green to brown – or even almost black as they mature. Older larvae have a dusky dorsal stripe, speckled with white and a yellowish, light green or dusky brown stripe low down on the sides. The larvae are 40–50 mm long when fully grown.



1. Cabbage moth generally overwinters as a pupa in the soil, although it may also overwinter as a larva.
2. Adult moths (first generation) emerge from pupae and lay eggs in batches of up to 50, which may be hard to detect.
3. Larvae feed on leaves and pupate in a cocoon in the soil.

4. Adult moths (second generation) emerge from pupae and lay eggs.
5. Larvae feed on leaves and pupate in a cocoon in the soil.

The second generation is the most damaging to brassica crops, with large larvae present quite late in the season.

Management

Non-chemical control

Several polyphagous predators attack this pest. The eggs or larvae may also be parasitised by certain species of wasps or flies, which eventually kill the larvae. The larvae continue to feed for some time after they have been parasitised, so crop damage is not reduced immediately. Larvae may also be killed by viruses. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Biological control with egg parasitoids (*Trichogramma* spp.) has been investigated overseas, but not in the UK. Although some biopesticides may be effective, some products based on *Bacillus thuringiensis* (Bt) are relatively ineffective.

Although sources of resistance in brassicas have been identified, no host resistance is available in commercial cultivars.

Monitoring

Use pheromone traps to catch male moths.

Thresholds

None established.

Insecticide resistance

None known.

Cabbage moth larva

Adult cabbage moth

Cabbage moth larvae

Cutworms/noctuid moths e.g. *Agrotis segetum*

Crops affected

Alliums	**Carrots**	Cereals	Field beans	**Lettuce**
Oilseeds	**Peas**	**Potatoes**	**Sugar beet**	**Vegetable brassicas**

Importance

The term 'cutworm' applies to various moth larvae, most being species of noctuid moths and the turnip moth (*Agrotis segetum*), in particular. The name derives from the fact that larvae feed on plant roots and stems underground, sometimes severing the stem. Although sporadic pests, damage can be severe, leading to plant loss and reduced plant quality.

Risk factors

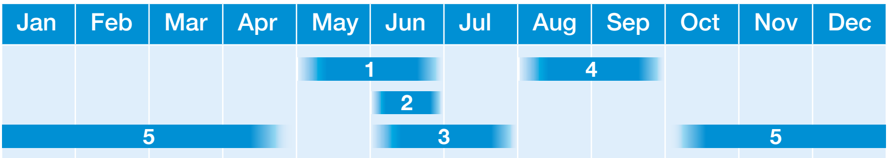
- The most susceptible crops are lettuce, leeks and red beet
- Moderately susceptible crops include brassicas, carrot, celery, parsnip and sugar beet
- The least susceptible crops are onion, potato, swede and turnip
- Damage is most severe in light, sandy soils – especially in hot, dry years

Life cycle, identification and symptoms

Adult turnip moths have a wingspan of about 40 mm. The forewings are pale greyish-brown with dark brown markings that include rings and lines.

The eggs are globular, about 5 mm in diameter and white, later turning cream with reddish-yellow markings and an orange band.

Fully grown caterpillars are greyish-brown and about 40 mm long, curling into a 'C' shape when disturbed. Adults and larvae are generally nocturnal.



1. Adult turnip moths lay eggs on plants or on plant matter in the soil.
2. Eggs hatch in around 8–24 days, depending on temperature, and larvae feed on the aerial parts of plants.
3. Following a further 10–20 days, the larvae go through a second moult and begin feeding on roots below ground.
4. A second generation of turnip moths may emerge in late summer, but the caterpillars of this generation do not appear to be damaging.
5. The pest overwinters as the larvae of the second generation, with pupae forming in April–May.

The life cycles of other species may vary from this pattern. For example, *Euxoa nigricans* (garden dart moth) lays eggs in the late summer, which hatch in the following spring. The larvae feed on beet seedlings, during April and May, before pupating.

Cutworm damage can kill seedlings and young plants. Larvae may move along the rows of crops, such as lettuce or leek and cut plants off, one after another. Similar to slugs, cutworms make cavities in stems, rhizomes, tubers and roots of large plants. Damage to root crops may not be evident until harvest.

The potato stem borer attacks sugar beet, potatoes and other crops. In sugar beet, it tunnels inside the crown and upper part of the root of young plants, causing roots to blacken.

Management

Non-chemical control

Irrigation can be an effective method of control for young larvae while feeding aboveground. To date, biological control with predators or parasitoids has not been investigated in the UK. Pesticides based on microbial control agents (for example, *Bacillus thuringiensis*, Bt) may be effective.

Monitoring

Catch male moths in pheromone traps.

Use weather-based models to predict the rate of development of turnip moth eggs, the level of rain-induced mortality among young larvae and target dates to apply irrigation or insecticides.

AHDB Pest Bulletin provides monitoring and forecasting information for this pest.

Thresholds

None established.

Insecticide resistance

None known.

Adult turnip moth

Cutworms

Cutworm damage to sugar beet

Diamond-back moth *Plutella xylostella*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Diamond-back moth infests crops sporadically throughout the UK. The larvae can damage the foliage of cabbage, cauliflower, broccoli, Brussels sprout, kale, Chinese cabbage, swede, turnip, oilseed rape and radish. Damage can be extensive, but losses depend on the effect on plant growth and quality. Management is particularly important to protect the marketable part of the plant (cabbage, cauliflower, broccoli and Brussels sprout). Plants with low levels of damage usually survive, but this may affect uniformity within the crop.

Risk factors

- Weather that favours migration from continental Europe increases the risk. The moth does not presently overwinter in the UK in large numbers. The moths are relatively poor flyers, but may be transported long distances by wind

Life cycle, identification and symptoms

Adult moths are about 6 mm long, brownish, with three light brown-to-white triangular marks on the trailing edge of each forewing. When at rest, the triangular marks meet to form diamond shapes.

The eggs are yellow and laid singly or in small groups, mainly alongside the midrib or leaf veins.

The larva is light green and has a tapering body that is widest in the middle. Larvae wriggle violently when disturbed. Fully grown larvae (15 mm) construct a flimsy cocoon on the leaf surface before developing into a pupa about 9 mm long.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				1	2	2	2	1			

Relative risk of egg laying and damage:

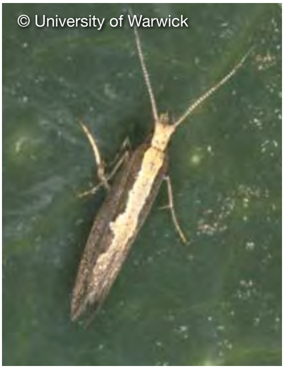
1. Low.
2. High.

The rate of development of diamond-back moth is dependent on temperature. More generations occur in warm locations. In the UK, depending on when moths arrive, there may be two to three generations per year. Eggs may hatch within 2–3 days of being laid and a complete generation takes about 5 weeks at 15°C.

Larvae consume the foliage of most types of brassica crop. They eat almost all leaf material (at any age), except the upper epidermis, creating translucent 'windows'. Large infestations destroy leaves.

The life cycles of other species may vary from this pattern. For example, *Euxoa nigricans* (garden dart moth) lays eggs in the late summer, which hatch in the following spring. The larvae feed on beet seedlings, during April and May, before pupating.

Cutworm damage can kill seedlings and young plants. Larvae may move along the rows of crops, such as lettuce or leek and cut plants off, one after another. Similar to slugs, cutworms make cavities in stems, rhizomes, tubers and roots of large plants. Damage to root crops may not be evident until harvest.



Adult diamond-back moth

Diamond-back moth larvae on cauliflower leaf

Diamond-back moth larval feeding damage

Management

Non-chemical control

Physical and cultural approaches (crop covers using fine mesh netting, companion planting and trap crops) can help, but are not as effective as insecticides.

To date, biological control with predators or parasitoids has not been investigated in the UK. Pesticides based on microbial control agents (*Bacillus thuringiensis*, Bt) or viruses can be effective.

Monitoring

Catch male moths with pheromone traps.

AHDB Pest Bulletin provides monitoring information for this pest.

Thresholds

None established in the UK.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

Elsewhere in the world, diamond-back moth populations have developed resistance to almost all of the insecticide groups to which they have been repeatedly exposed.

Garden pebble moth *Evergestis forficalis*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Garden pebble moth is a localised pest. Feeding by the larvae damages foliage. Larvae sometimes mine into the hearts. Frass (droppings), larvae and silk webbing can contaminate fresh produce.

Risk factors

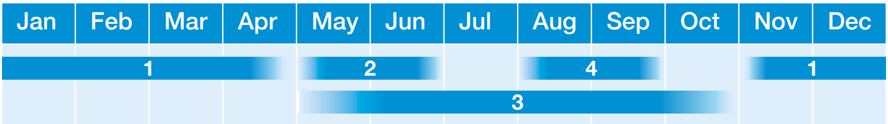
- The larvae hide themselves within plant foliage, so infestations may not be detected until damage has already occurred

Life cycle, identification and symptoms

Adults have a wingspan of 25–30 mm. The forewings are yellowish-white, with brown veins and are covered with a series of oblique brown lines and shaded areas.

Eggs are shiny, oval and flattened. They are initially translucent before becoming yellow.

Young larvae are yellowish-green, but later become glossy pale green with yellowish mid-dorsal and lateral stripes. Fully grown larvae are 18–20 mm long with a row of black spots along each side.



Adult garden pebble moth

1. Pupae overwinter in the soil.
2. Adults (first generation) emerge and lay eggs in batches of about 20 on the undersides of leaves.
3. Larvae feed on the underside of leaves, frequently as a group within leaf folds and beneath protective silk webbing. The larvae pupate in cocoons in the soil.
4. Adults (second generation) emerge and lay eggs.

The second generation is the most damaging to brassica crops.

Management

Non-chemical control

Several polyphagous predators attack this pest. The eggs or larvae may also be parasitised by certain species of wasp or fly, which eventually kill the larvae. The larvae continue to feed for some time after they have been parasitised, so crop damage is not reduced immediately. Use the SAFE approach to encourage natural enemies – see pages 185–186.

To date, biological control with predators or parasitoids has not been investigated in the UK. It is not clear how susceptible the larvae are to products based on *Bacillus thuringiensis* (Bt).

Monitoring

Catch male moths in pheromone traps.

Thresholds

None established.

Insecticide resistance

None known.

Young garden pebble moth larva

Garden pebble moth larva

Garden pebble moth damage

Large white butterfly *Pieris brassicae*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Feeding by the larvae of the large white butterfly damages foliage and can skeletonise leaves, particularly on field margins. Frass (droppings) and the larvae can contaminate fresh produce.

Risk factors

- The larvae feed within plant foliage and infestations may not be detected until damage has occurred
- Eggs are usually laid in large numbers on only a few plants, so these can be severely damaged while other plants escape
- This species is not as problematic as the small white butterfly

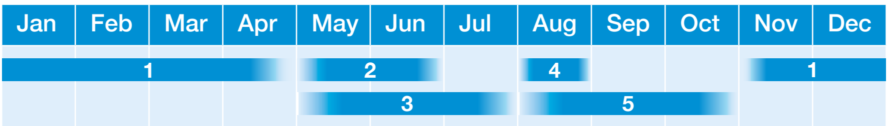
Life cycle, identification and symptoms

Adult butterflies have a wingspan of 60–70 mm. The tips of the forewings are black and the female has large black spots on the upper surface of each forewing.

Eggs are yellow and flask-shaped (1.5 mm high and 0.6 mm at their base).

Young larvae are initially pale green, turning mottled blue-green. Larvae are 25–40 mm long when mature, with three yellow longitudinal stripes along the body. Larvae are covered with black markings and groups of short, stiff white hairs that arise from fleshy protuberances along the body.

The pupae are grey-green and attached to a vertical or overhanging surface by a silken girdle.



1. Pupae overwinter away from the host plant.
2. Adults (first generation) emerge from pupae and lay eggs in batches of 20–100 on the undersides of leaves.
3. Larvae feed/pupae form (first generation).
4. Adults (second generation) emerge from pupae and lay eggs.
5. Larvae feed/pupae form (second generation).

The second generation is the most damaging to brassica crops.

Management

Non-chemical control

Several polyphagous predators attack this pest, including some birds and large beetles.

Natural mortality of larvae can be high thanks to a species of parasitic wasp (*Cotesia glomerata*) and also as a result of infection by a baculovirus. The small, bright yellow cocoons of the parasitic wasps can often be seen clustered alongside dead or dying larvae from which they have emerged. The larvae continue to feed for some time after they have been parasitised, so crop damage is not reduced immediately. Use the SAFE approach to encourage natural enemies – see pages 185–186.

The larvae can be controlled with products based on *Bacillus thuringiensis* (Bt). Control by inundative releases of egg parasitoids (*Trichogramma* spp.) and the use of fungal pathogens has not been evaluated in the UK.

Eggs are laid in batches and the larvae feed gregariously, so it is relatively easy to spot plants damaged by large white butterfly. The pest can be controlled by either hand-picking them, or avoiding the affected plants at harvest.

Monitoring

Capture adult butterflies in yellow water traps or on yellow sticky traps.

Thresholds

None established.

Insecticide resistance

None known.

Adult large white butterfly

Large white butterfly larvae

Large white butterfly eggs

Young large white butterfly larvae

Leek moth *Acrolepiopsis assectella*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Leek moth larvae (caterpillars) make ‘shot holes’ in folded leaves. This damage and associated decay render leeks unmarketable. Onions, garlic and chives can also be hosts for this species.

Adult leek moth

Risk factors

- Mainly distributed in warm locations towards the south of the UK, especially around the coast

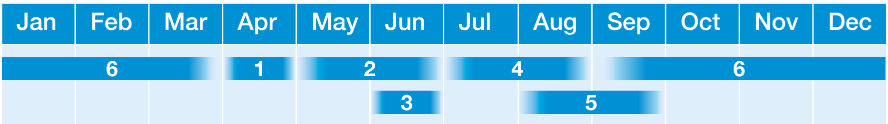
Life cycle, identification and symptoms

The adult moth has a wingspan of 15 mm. The forewings are slender and narrow and have a variable brown colour, with paler scales near the apices. There is a conspicuous white triangular mark halfway along the rear margin of each forewing. The rear margins of the forewings are fringed with pale-coloured hairs.

The eggs are oval-shaped, white, iridescent and about 0.4 mm in diameter.

When fully grown, the larva is 13–14 mm long. It has a brown or yellow head and a yellowish-green body, with inconspicuous grey-brown patches, especially around the spiracles. There are yellow plates on the first and last segments.

The pupa is about 6 mm long and brown.



1. Adult moths emerge in April and lay eggs (up to 100 per female) singly on foliage towards the base of the plant.
2. The larvae feed during May and June. At first, they mine the leaves, leaving the epidermis intact, but then bore through the folded leaves to feed near the centre.
3. The larvae pupate in flimsy silken cocoons attached to the host plants.
4. Adults (second generation) emerge and lay eggs.
5. Larvae (second generation) feed.
6. Pupae overwinter.

When young larvae mine the leaves of leeks, it leads to patches of papery, necrotic tissue. Older larvae make ‘shot holes’ in folded leaves. Severely damaged leaves sometimes rot and, if extensive, the plant dies.

Leek moth larva

Management

Non-chemical control

To prevent reinfestation, it is necessary to practice good crop rotation and locate crops away from previously infested soil. Crop debris can be destroyed to kill pupae. Natural enemies, including parasitic wasps, can attack leek moth larvae. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Biopesticides based on *Bacillus thuringiensis* (Bt) can control the larvae. The use of insect-pathogenic nematodes appears to be effective.

Leek moth damage

Monitoring

Catch male moths with pheromone traps.

Thresholds

None established in the UK.

Insecticide resistance

None known.

Leek moth damage

Pea moth *Cydia nigricana*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	**Peas**	Potatoes	Sugar beet	Vegetable brassicas

Importance

Pea moth is one of the most economically damaging pests of UK-grown peas, mainly because larvae feeding inside pods reduce pea quality.

In vining peas, damaged peas cannot be removed mechanically, so this can result in crop rejection.

In combining peas for premium markets, the merchant removes damaged peas and the price paid is proportionally reduced.

Damage in peas for animal feed is not important and reductions in yield are rarely significant.

Risk factors

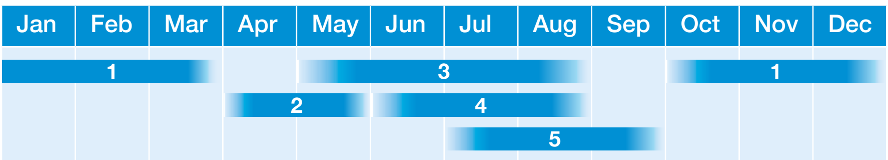
- Any pea crop in flower or in pod in June or July can be attacked
- Risk is greater where there has been severe damage in previous crops. Control may only be justifiable in these cases
- Early maturing and early or late-sown peas may miss the moth flight period, reducing risk

Life cycle, identification and symptoms

The moths are dull grey-brown with white and black markings on the leading edge of each forewing. They are approximately 6 mm long, with a 15 mm wingspan.

The eggs are small and flattened.

The caterpillars are pale yellow with a black head and legs. When mature, they are around 10 mm long. They have a brown ring on the prothorax, with eight brown dots on the following segments.



1. Overwinter in cocoon about 10 cm below ground.
2. Caterpillar emerges to form a second cocoon at soil surface. Pupation occurs upon leaving this cocoon.

3. Moths emerge in late May/early June and lay eggs singly or in small groups on leaves and stipules of pea plants from early June until mid-August.
4. Hatched caterpillars enter young pods to feed. Pea pods rarely contain more than two caterpillars each. Damaged pods may appear yellow and ripen early.
5. Mature caterpillars bite their way out of their pod and descend to the soil to form a cocoon underground.

Pea moth

Pea moth larva

Pea moth larva

Management

Non-chemical control

Large pea moth populations can develop where pea crops remain in the field to full maturity. Therefore, combining pea areas are likely to be a reservoir. Plough in unharvested green peas before larvae leave dried pods. Early maturing and early or late-sown peas may miss the moth flight period, so may be unaffected. Pea moth is attacked by four species of parasitic wasp and a pathogenic fungus.

Monitoring

Use pheromone traps to catch males. Place traps in crops by mid-May. Examine at 2-day intervals. Use monitoring results and a computer model (use daily minimum and maximum temperatures) to predict egg development. Use the information to target sprays at newly hatched larvae, before they enter pods. See **pgro.org** for the latest pea moth alerts.

Thresholds

Dry harvested peas for human consumption

Ten or more moths caught in traps on two consecutive occasions.

Vining peas

Use traps to determine if moths are present. Growers should be guided by the factory fieldsperson: even very small infestations can lead to rejection.

Insecticide resistance

None known.

Silver Y moth *Autographa gamma*

Crops affected

Alliums	**Carrots**	Cereals	**Field beans**	**Lettuce**
Oilseeds	**Peas**	Potatoes	**Sugar beet**	**Vegetable brassicas**

Importance

Feeding by the larvae (caterpillars) of the silver Y moth can cause damage to foliage. Frass (droppings) and the larvae can contaminate fresh produce.

Risk factors

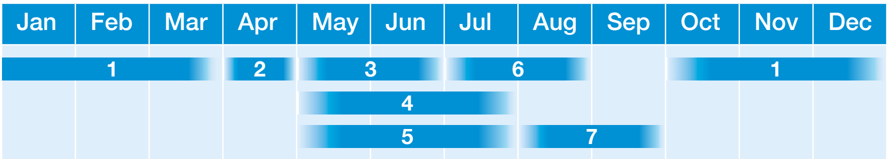
- Lettuce is one of the most susceptible crops
- Infestations may not be detected until after damage has occurred
- It is a migratory pest and crops in the south and east of England may be at greater risk. Large numbers of moths can arrive suddenly

Life cycle, identification and symptoms

Adults are grey to greyish-brown with a distinct silver Y mark on each forewing and a wingspan of 35–40 mm.

Eggs are oval (0.5–0.6 mm diameter) and white, darkening close to hatching.

The larvae are 24–40 mm long, green (ranging from bright green to very dark green) and have a dark green dorsal line edged with white. A light yellow line runs over the sides. The caterpillars ‘loop’ as they walk.



1. This species cannot survive the winter in the UK. It overwinters overseas.
2. Immigrant moths may arrive. Migration patterns vary widely from season to season.
3. Immigration risk period peak.
4. Eggs laid singly on susceptible host plants. Female moths lay an average of 150–650, eggs but can lay up to 1,500.
5. Larvae feed.
6. Mature larvae pupate on leaves within a loose web-like cocoon.
7. Moths migrate southwards.

It is estimated that 10–240 million immigrants reach the UK each spring and that summer breeding results in a fourfold increase in the abundance of the subsequent generation of adults, all of which emigrate southwards in the autumn.

Adult silver Y moth

Management

Non-chemical control

Several polyphagous predators attack this pest. The larvae may also be parasitised by certain species of wasp or fly, which eventually kill the larvae. The larvae continue to feed for some time after they have been parasitised, so crop damage is not reduced immediately. Larvae may also be killed by viruses. Use the SAFE approach to encourage natural enemies – see pages 185–186.

To date, biological control with predators or parasitoids has not been investigated in the UK. Pesticides based on microbial control agents (for example, *Bacillus thuringiensis*, Bt) may be effective.

Adult silver Y moth

Monitoring

Pheromone traps can trap moths in very high numbers.

Light traps, run by moth enthusiasts, also catch moths. In Dorset, the first silver Y moths were captured on 26 April 2013 (a cold spring) and on 28 March 2012 (a warmer spring).

AHDB Pest Bulletin provides monitoring information for this pest.

Silver Y moth larva

Thresholds

For vining peas, the threshold is reached when the cumulative catch (pheromone traps) exceeds 50 moths by the first pod stage (growth stage 204).

For sugar beet, the threshold is five caterpillars per plant.

Insecticide resistance

None known.

Small white butterfly *Pieris rapae*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	**Vegetable brassicas**

Importance

Feeding by the larvae of the small white butterfly can damage foliage. Frass (droppings) and the larvae can contaminate fresh produce.

Risk factors

- Larvae are well-hidden in foliage and infestations may not be detected until after damage has occurred
- The second generation usually causes more damage than the first

Adult small white butterfly on kale

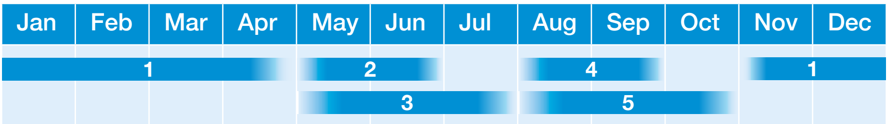
Life cycle, identification and symptoms

Adults are white butterflies with a wingspan of 50 mm. Forewings have conspicuous black tips. The female has two small black spots on the upper surface of each forewing, while the male has one black spot in the middle of each forewing.

Eggs are yellow and bottle-shaped.

The larvae are solitary and have a green velvety appearance, with a dorsal yellow line and elongate yellow patches along their sides. Larvae are 25 mm in length when mature.

When fully grown, the larva usually pupates on the plant, to which it is attached by a silken girdle.



1. Pupae overwinter.
2. Adults (first generation) emerge and eggs are laid singly on the undersides of leaves of host plants.
3. Larvae feed/pupae formed (first generation).
4. Adults (second generation) emerge and lay eggs.
5. Larvae feed/pupae formed (second generation).

Management

Non-chemical control

Several polyphagous predators attack this pest, including some birds and small beetles. Natural mortality of larvae can be high thanks to parasitic wasp species. The larvae continue to feed for some time after they have been parasitised, so crop damage is not reduced immediately. Use the SAFE approach to encourage natural enemies – see pages 185–186.

The larvae can be controlled with products based on *Bacillus thuringiensis* (Bt). The possibility of control with other biopesticides is under evaluation in the UK.

Small white butterfly pupa

Small white butterfly larva

Monitoring

Capture adult butterflies in yellow water traps or on yellow sticky traps.

Thresholds

None established in the UK.

Insecticide resistance

None known.

Parasitised small white butterfly larva

Adult small white butterfly

Small white butterfly egg

Swift moths *Hepialus humuli* and *Korscheltellus lupulinus*

Crops affected

Alliums	**Carrots**	**Cereals**	Field beans	**Lettuce**
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Swift moths include the ghost moth (also known as the ghost swift moth), *Hepialus humuli*, and the common swift or garden swift moth *Korscheltellus lupulinus* (formally *Hepialus lupulinus*). They are minor and localised pests.

The larvae cut off plants just below ground level or tunnel into roots or stems.

Male ghost moth

Risk factors

- The ghost moth is common in grassland, so any crop following a grass ley is most vulnerable to attack
- Lettuce is especially vulnerable to damage from the common swift moth

Life cycle, identification and symptoms

Adult common swift moths have a wingspan of 30–40 mm. They typically have dark brown forewings with white streaks that meet to make a 'v' shape, though some individuals are plain buff or brown with no pattern.

The larvae are white and the head is orange-red and well protected. They reach 30–40 mm when fully grown.

Female ghost moth

Adult ghost moths have a wingspan of 40–65 mm. The male is silvery white and the female is pale buff, with a series of pale pink markings on the forewing.

The eggs are oval, shiny and white. The larvae are similar to those of the common swift moth.

Common swift moth

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
					1						
					2						
	3			4				3			

Ghost moth

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
					1	1					
					2	2					
3	3	3	3	4	4	3	3	3	3	3	3

1. Adult moths emerge in late May/early June.
2. Females lay about 200 eggs, dropped singly while the moth is flying.
3. Larvae feed underground, but severe damage occurs only during the late autumn and spring of the following year, especially in February/March.
4. Larvae pupate. The larvae of the ghost moth usually feed for 2 years before pupating.

Common swift moth

Common swift moth larva

Management

Non-chemical control

Cultivation may kill larvae.

Several polyphagous predators attack these pests, including birds and moles. The larvae may also be parasitised by certain species of wasp that eventually kill the larvae. The larvae continue to feed for some time after they have been parasitised, so crop damage is not reduced immediately. Larvae may also be killed by fungal disease. Use the SAFE approach to encourage natural enemies – see pages 185–186.

To date, biological control has not been investigated in the UK.

Monitoring

Apart from the damage they cause, these pests are difficult to monitor.

Thresholds

None established in the UK.

Insecticide resistance

None known.

Flax tortrix moth (*Cnephasia asseclana*)

Crops affected

Alliums	Carrots	Cereals	Field beans	**Lettuce**
Oilseeds	**Peas**	Potatoes	**Sugar beet**	Vegetable brassicas

The caterpillar of the flax tortrix moth ties together the upper leaves of pea plants with a fine web and feeds within the bunched leaves.

Damage shows in spring, just before flowering, but is not severe and will not cause yield loss. By harvest, caterpillars pupate and moths leave the crop. Therefore, control is unnecessary.

Flax tortrix moth damage

Pests: Nematodes

155 An introduction to nematodes

156 Beet cyst nematode (*Heterodera schachtii*)

158 Free-living nematodes (numerous species)

160 Potato cyst nematode (*Globodera pallida* and *G. rostochiensis*)

162 Stem nematode (*Ditylenchus dipsaci*)

164 Minor and/or emerging pests

164 Cereal cyst nematode (*Heterodera avenae*)

165 Pea cyst nematode (*Heterodera goettingiana*)

166 Root knot nematode (*Meloidogyne* spp.)

An introduction to nematodes

Nematodes (Nematoda) are a diverse group of slender worms. They are not insects.

Life cycle

More than half of nematode species are likely to be parasitic. Some (often referred to as eelworms) damage plant health, but other species are predatory and control other pests.

Defining features

Nematode species are difficult to distinguish and most require magnification to be seen.

Free-living nematode

Root lesion nematode

Stubby root nematode head region, showing the curved spear used to penetrate plant roots

Male stubby root nematode

Beet cyst nematode *Heterodera schachtii*

Crops affected

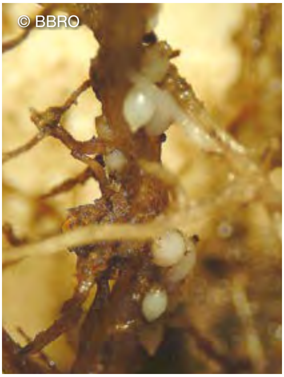
Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	**Vegetable brassicas**

Importance

Beet cyst nematode (BCN) is one of the most important pests of sugar beet. It also infests related crops, such as spinach, mangold, fodder and red beet and can complete its life cycle on some brassica crops, such as oilseed rape, cabbage and Brussels sprout.

In sugar beet, yield reductions of 30–60% occur, depending on the level of infestation.

The yellow beet cyst nematode (*Heterodera betae*) is present in parts of Europe, but not in the UK.



Cysts of beet cyst nematode

Beet cyst nematode damage

Risk factors

- Cysts are spread in soil, attached to beet roots, farm machinery and footwear, or by floodwater
- Most common in sandy or peaty soils
- Oilseed rape and other brassica seed crops are particularly efficient hosts and can lead to a quick build-up of the pest
- BCN is most likely to be found on sites with close rotations of beet and/or brassica crops and where host weed species, such as charlock and fat hen, are not controlled

Life cycle, identification and symptoms

The cysts are lemon-shaped (0.5 x 1 mm) and, initially, white, turning brown as they mature. They are present on the roots of beet from the seedling stage until harvest. They can easily be confused with grains of sand. It is easier to see them on gently washed roots using magnification.

The juveniles have slender, transparent bodies measuring 0.5 mm in length and are too small to be seen without magnification.

Cysts in the soil can hatch with or without the presence of hosts, but root stimulants, produced by host plants, encourage additional hatching and attract the larvae to the roots.

The juveniles move through the roots. After mating, males return to the soil, while females remain within the root and begin to swell, forming cysts that can fall off into the soil to repeat the cycle. Cysts can remain viable in the soil for many years, containing up to 600 eggs.

The life cycle completes in 300 degree-days above a base temperature of 10°C. In northern Europe, it can complete two or three generations per year, depending on weather conditions.

Crop damage is usually evident as patches of stunted beet, which wilt easily in dry periods. Affected plants produce many lateral roots, in response to the root damage: an effect known as 'bearding'.

Bearding symptoms caused by beet cyst nematode

Symptoms of beet cyst nematode infestation

Management

Non-chemical control

Widen the rotation to reduce cyst numbers. Do not use oilseed rape and other brassica seed crops as break crops in cereal rotations that also include sugar beet.

Nematode-resistant brassica catch crops, such as white mustard and oil radish, can prevent an increase in inoculum for the following beet crop. Sown in the autumn, they encourage eggs to hatch but are resistant to colonisation by the juveniles.

Nematode-tolerant sugar beet varieties are on the BBRO Recommended List.

Monitoring

Sample soils and use commercial services to determine egg/larval concentration in the soil.

Thresholds

Thresholds vary widely across Europe. In the UK, there is an economic benefit associated with BCN-tolerant varieties above two eggs and larvae per gram of soil.

Insecticide resistance

None known.

Free-living nematodes numerous species

Crops affected

Alliums	**Carrots**	Cereals	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	**Sugar beet**	Vegetable brassicas

Importance

Free-living nematodes (FLN) reduce crop quality and yield by feeding on the roots and are important as virus vectors. Stubby root nematodes (*Trichodorus* spp. and *Paratrichodorus* spp.) and needle nematodes (*Longidorus* spp.) are the most damaging species.

Stubby root nematodes transmit *Tobacco rattle virus* (*TRV*) to potato, producing an internal disorder of the tubers called spraing. This does not affect yield, but reduces tuber quality and can make them unacceptable for sale. Although FLN can also transmit *TRV* to sugar beet, its effects are less serious than the direct damage.

Yield reductions can occur in most crops, but are most common in potatoes, carrots, parsnips and sugar beet. Yield losses of up to 17 t/ha have been estimated in sugar beet. Nematode feeding can also reduce root crop quality.

Risk factors

- FLN are generally most numerous in sandy and other light, open-textured soils
- Needle nematodes are found in a variety of soil types, but favour relatively undisturbed conditions
- Wet growing seasons and regular irrigation can increase the risk of damage because the nematodes require adequate soil moisture to move between plants
- In potatoes, most infections occur soon after tuber initiation
- Some potato varieties show spraing symptoms more readily than others

Life cycle, identification and symptoms

Stubby root nematodes have an extremely high rate of reproduction when soil temperatures are between 15°C and 30°C. They feed on various crop and non-crop species throughout the year.

Needle nematodes multiply relatively slowly on various crop and non-crop species. Several generations occur each year, so both adults and juveniles occur together.

In many crops, feeding by stubby root nematodes causes a proliferation of thickened, ‘stubby’ roots. This causes poor top growth and reductions in yield and can make the plant more susceptible to drought stress and mineral deficiencies.

Spraing appears as chestnut-brown arcs, circles or lines through the tuber. Spraing-affected tubers are associated with short stems and crinkled, malformed and stem-mottled (discoloured) leaves. The tubers these produce can also contain brown flecks.

FLN feeding on taproots can cause the root tip to die and lateral roots to take over. In carrots, parsnips and sugar beet, this feeding can cause multiple taproots to form, known as 'fanging' (in carrots and parsnips) or 'docking disorder' (in sugar beet). Affected plants are stunted and healthy plants are often seen next to stunted plants, a symptom known as 'chick and hen'.

Stubby root nematode damage to sugar beet seedlings

Carrot 'fanging' caused by nematodes

Management

Non-chemical control

In potatoes, use of healthy certified seed or propagating stock can prevent the introduction of nematodes to a field. In areas at greater risk from spraing, use varieties with a lower susceptibility to *TRV*. Rotating potatoes with non-host crops and lengthening the rotations (growing potatoes no more than one year in six) will reduce nematode populations. Weeds can act as alternative hosts and a source of *TRV*.

Monitoring

Determine the number of FLN by soil extraction; a service offered by several accredited laboratories. Some can also detect whether or not the stubby root nematodes are carrying *TRV*. Transport soil samples carefully to protect nematodes from damage.

Thresholds

In sugar beet, severe symptoms may occur in soils with *Trichodorus* populations of more than 1,000 nematodes per litre of soil, or with *Longidorus* populations of more than 100 nematodes per litre of soil.

Insecticide resistance

None known.

Potato cyst nematode *G. pallida* and *G. rostochiensis*

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	**Potatoes**	Sugar beet	Vegetable brassicas

Importance

Potato cyst nematode (PCN) is the most important UK potato pest. There are two species: *Globodera pallida* (white PCN) and *G. rostochiensis* (yellow PCN). They damage the roots of potatoes, which can result in poor growth, wilting during periods of water stress, early senescence and a reduction in tuber yield by as much as 80%.

Risk factors

- The nematode is mainly spread by the movement of cysts in soil attached to potato tubers, farm machinery or footwear. Cysts can also be spread by wind and floodwater
- Cultivars vary in their tolerance to PCN, with some still able to produce an acceptable yield in the presence of PCN
- Varieties resistant to *G. rostochiensis* are available and will help to minimise PCN build-up. However, there is only partial resistance to *G. pallida*

Life cycle, identification and symptoms

These nematodes have slender, transparent bodies, reaching approximately 1 mm in length. As the females mature, they swell, forming spherical cysts 1 mm in diameter, which are initially white or cream. At this stage, they are visibly attached to roots. As the females mature and die, the cysts develop a reddish-brown hard skin.

In the presence of the crop, large numbers of eggs hatch in April/May and juveniles infest crop roots.

In the absence of the crop, smaller numbers hatch in April/May and these die, unless they find a host.

Nematodes continue to hatch and invade crop roots over the summer.

Mature cysts become detached from the roots at harvest and can remain in the soil for up to 10 years. Each cyst contains hundreds of eggs.

The nematodes damage the roots and affect yield, even when no symptoms are evident in the haulm. Severely infected roots may die, resulting in stunted, often chlorotic, plants with a patchy distribution.

Management

Non-chemical control

An IPM approach is required to deal with PCN. Select resistant or tolerant cultivars (see the Potato Variety Database on the AHDB website). Use PCN-free certified seed (in seed crops or potatoes for export). Limit the movement of soil. Control volunteer potatoes. Extend rotations (to at least 8 years). In the absence of the crop, nematode numbers will gradually decline.

Monitoring

Use soil extraction to determine PCN infestation levels (eggs per gram of soil) by accredited laboratories.

Under EU Directive 2007/33/EC, only plant seed potatoes or potatoes for export on land that is free of PCN infestation, via an official soil test by a Plant Health and Seed Inspectorate (PHSI) inspector. The growing of ware potatoes is permitted, subject to the implementation of a Control Programme (see **fera.defra.gov.uk/plants/planthealth**).

Thresholds

To manage PCN population levels (eggs per gram) and species, seek advice from an agronomist and consider varieties, rotation and cultural control methods.

- Low – 1–10 eggs per gram – nematicide use is recommended
- Medium – 10–20 eggs per gram – nematicide treatment is highly recommended
- High – >20 eggs per gram – take into account all factors and, if appropriate, consider other ground

Insecticide resistance

None known.

White PCN cysts

Yellow PCN cysts

Stem nematode *Ditylenchus dipsaci*

Crops affected

Alliums	Carrots	**Cereals**	**Field beans**	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

Importance

A destructive pest, the different races of stem nematode have different host preferences. They infested seedlings or young plants and cause them to become deformed.

Risk factors

- Soil or host plants, including seed, often transfer these nematodes, including to previously 'clean' fields
- They are also spread by rain, floodwater and wind

Life cycle, identification and symptoms

Stem nematodes are slender, colourless and impossible to see without magnification. The adult body is just over 2 mm long and tapers at each end.

Stem nematodes are parasites that live within plant tissues. Both males and females, which can occur in large numbers, feed and break down cell walls. Females lay up to 500 eggs, with four moults.

The stem nematode can survive, mainly as desiccated fourth-stage juveniles, for several years. These tend to aggregate at the surface of heavily infested plant tissue to form clumps of 'nematode wool'. The nematodes become active again when the wool becomes moist. In wet soil, they can live in the absence of host plants for more than 1 year.

Onions

Infested seedlings or young plants swell at their bases and have malformed and twisted leaves. Infested tissue has a loose, puffy texture and the epidermis is dull in appearance (known as 'bloat'). Rotting occurs at soil level and badly infested plants can be pulled to leave their roots in the soil. Eventually, infested plants die. Minor infestations may go unnoticed, but can hasten the deterioration of stored bulbs.

Sugar beet

The tissues of infested seedlings become swollen and spongy. Galls may form and the growing points become deformed or die, leading to multiple crowns and small, distorted leaves. In the autumn, the damaged crown may rot, encouraging secondary pathogens. Usually, relatively few plants are affected in any one field.

Beans

Damage usually shows as stem discolouration.

Oats

The base of the plant becomes swollen and the leaves are pale, stunted and twisted.

Management

Non-chemical control

As stem nematode races are highly host-specific, a 3-year crop rotation can deprive the nematodes of a suitable host and starve the population. Weed control also decreases susceptible hosts and the ability of the nematodes to survive and spread.

Monitoring

Consider testing soil for the presence of nematodes. Dissection of plant tissue and immersion in water, usually conducted in a laboratory, can confirm the presence of the pest.

Thresholds

There are no validated thresholds for stem nematode. The presence of stem nematodes in soil usually means the land is avoided for cropping with onions.

Insecticide resistance

None known.

Stem nematode damage in garlic. Affected and healthy bulb shown.

Stem nematode damage to sugar beet

Stem nematode damage to bean plant

Minor and/or emerging pests

Cereal cyst nematode (*Heterodera avenae*)

Crops affected

Alliums	Carrots	**Cereals**	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Cereal cyst nematode is the main nematode pest of cereals. In the UK, it is more damaging to oats than to other cereals.

In the 1960s, when barley began to be intensively grown in the UK, numbers of this pest initially increased. However, infestations then started to decline, mainly because fungal parasites of the nematode favoured by intensive cereal growing.

Infected crops show patches of stunted plants, sometimes tinged with red or purple. Infected oats have a typical bushy root system. Heavily affected plants show reduced tillering, but significant infestations of cereal cyst nematode are relatively rare.

Cereal cyst nematode eggs and larvae

Cereal cyst nematode damage

Pea cyst nematode (*Heterodera goettingiana*)

Crops affected

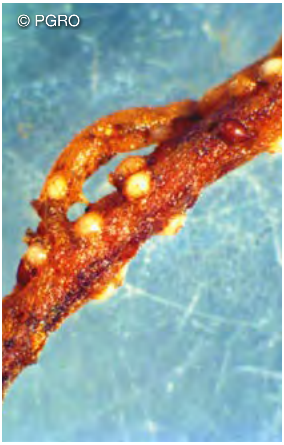
Alliums	Carrots	Cereals	**Field beans**	Lettuce
Oilseeds	**Peas**	Potatoes	Sugar beet	Vegetable brassicas

The pea cyst nematode attacks the roots of pea and beans, though the latter rarely shows symptoms. The pest is not ubiquitous and incidence varies from year to year.

Any symptoms appear in early summer before flowering, with areas of the crop becoming pale and stunted. Plants turn yellow and have an upright appearance, small leaves and may flower prematurely.

Pods often fail to develop and plants may die prematurely. Root systems are often poorly developed and contain tiny, white, lemon-shaped cysts containing nematode eggs. These later turn brown and can remain viable for up to 20 years.

Crops in areas with a long history of frequent pea cultivation and those on lighter, sandier soils tend to be at greatest risk. Yield losses can be sustained with soil populations of five eggs per gram of soil.



Pea cyst nematode cysts on root

Root knot nematode (*Meloidogyne* spp.)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

Root knot nematode is an important pest worldwide. Of the 50 described species, only a few infest sugar beet.

The life cycle is similar to that of the beet cyst nematode (see page 156). Infested plants are stunted and tend to wilt in warm weather. Root knot nematodes cause galls to form on the lateral roots of plants. Where early infestations are severe, plants may die.

Control methods include the use of granular nematicides, trap cropping, lengthening the rotation and control of weed hosts.

Root knot nematode symptoms

Pests: Slugs

169 An introduction to slugs

170 Slugs

170 Grey field slug (*Deroceras* spp.)

170 Garden slugs (*Arion hortensis* and *Arion distinctus*)

170 Keeled slugs (*Milax, Tandonia* and *Boettgerilla* spp.)

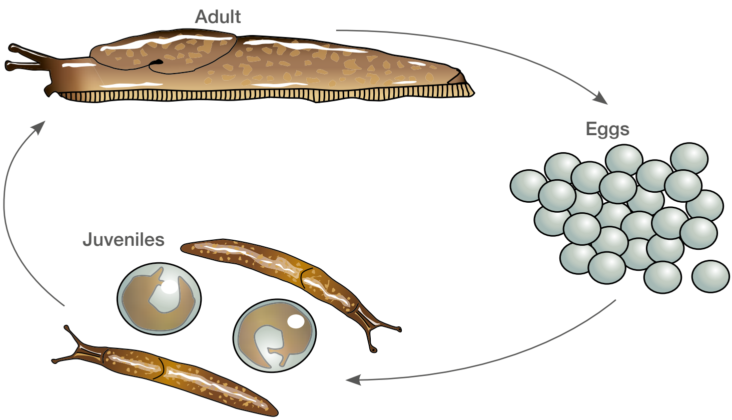
An introduction to slugs

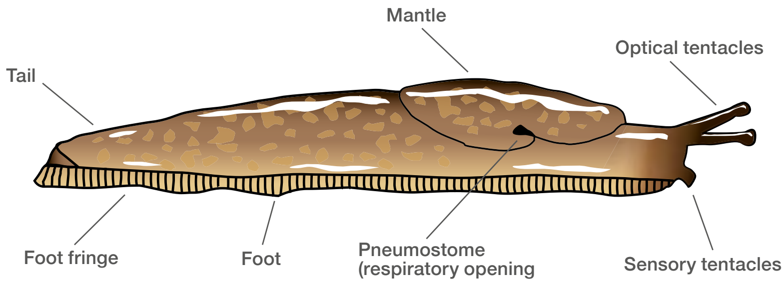
Generally, the term ‘slug’ (Gastropoda) is applied to any species of terrestrial gastropod mollusc that has no (or a very reduced or internal) shell.

Unlike insects, the juveniles that emerge from eggs appear very similar to the adult slugs. They do not undergo metamorphosis.

Defining features

Slugs are legless, unsegmented and boneless. Slugs’ bodies are mostly composed of water. Without a shell, slugs are prone to desiccation. They generate protective mucus and are usually most active on still nights, when the soil is wet and the atmosphere is humid (particularly just after rain). They hide in damp places during drier periods. Wind and heavy rain can decrease their activity.





Slugs

Key slug species

Grey field slug (*Deroceras reticulatum* and other *Deroceras* spp.)

Garden slugs (*Arion hortensis* and *Arion distinctus*)

Keeled slugs (*Milax, Tandonia* and *Boettgerilla* spp.)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	Sugar beet	Vegetable brassicas

Importance

Slugs can cause damage all year round, whenever weather and temperature conditions are suitable, but they are particularly damaging in autumn crops and potatoes.

In cereals, seed hollowing is a particular problem. Both cereals and oilseed rape are susceptible to leaf grazing until the four-leaf stage. In potatoes, slugs affect crop quality by mining the tubers and providing an entry point for fungal pathogens. For vegetables, attack in the early stages can cause plant loss and at later stages can lead to quality and contamination issues.

Grey field slugs

Risk factors

- The early stages of most crops and the early stages of tuber bulking in potatoes are most vulnerable
- Slug activity, survival and reproduction are dependent on moisture. The optimum temperature is 17°C
- Slugs are most abundant in heavy soils with high clay or silt content, with open, cloddy seedbeds allowing easy movement
- Damage is much greater after leafy crops. Crop residues or applications of manure, especially in the autumn, as well as weeds and volunteers, provide slugs with a source of food and shelter
- Lack of nutrients, poor drainage and weed competition can all result in slow crop growth, prolonging the vulnerable period of establishment
- Seed of oats and barley are less vulnerable than wheat seeds; however, they are still at risk following germination
- Spring-sown cereals are at lower risk than autumn-sown ones

Slug damage in oilseed rape

Slug damage in potato

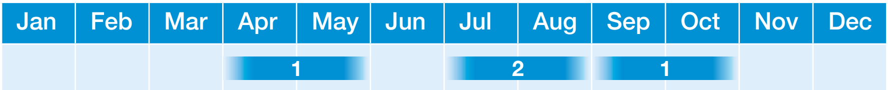
Life cycle, identification and symptoms

Grey field slugs are the most common and injurious species. They are usually grey or fawn and adults are 35–50 mm in length.

Garden slugs, also known as round-back slugs, are usually smaller than field slugs, with a dark upper body and a yellow to orange underside.

Keeled slugs are generally the largest pest species (50–75 mm long) and are grey-to-dark-brown or black with a ridge down the centre of the back.

Slugs can be active all year round, but the main breeding periods of the grey field slug *Deroceras reticulatum* and garden slug *Arion hortensis* are shown below.

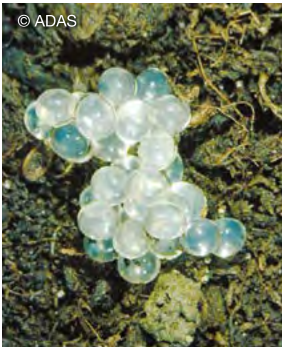


1. Peak breeding (field slugs).
2. Peak breeding (garden slugs).

All slug species are hermaphrodite (each individual is both male and female). While some species are self-fertile, most mate before laying eggs in batches of 10–50 in soil cavities, between clods, under stones or at the base of plants. Up to 500 eggs per slug may be laid over several weeks. Eggs develop slowly in the winter, but will hatch within a few weeks when the temperature starts to rise.

During their lifetime, slugs travel only a few metres from their hatching site, in a circular route, in search of food. They are active and feed throughout the year, whenever conditions are suitable.

Slug feeding causes seed hollowing, which prevents germination and causes leaf shredding and tuber damage. Leaf shredding can be especially damaging to seedlings. Feeding on potato tubers causes ragged holes on the surface and larger cavities within the tuber.



Slug eggs

Grey field slug

Management

Non-chemical control

Ploughing can reduce slug populations. However, even minimum tillage gives a considerable reduction in slug damage compared with direct drilling. A fine, consolidated seedbed is important and will protect seeds and prevent slugs accessing seedlings before emergence. Increase the sowing depth of wheat to 4–5 cm if the seedbed is cloddy.

Damage in potato crops is partly related to tuber maturity. Lifting potatoes as soon as possible can limit damage by minimising the time the crop is exposed to feeding.

Phasmarhabditis hermaphrodita is a parasitic nematode that attacks slugs and, unlike pellets, can target soil-dwelling slugs and not just those that are active on the soil surface.

Natural enemies include ground beetles, rove beetles, parasitoids, birds, amphibians and hedgehogs, so providing habitats for these species may help to control slug populations. Use the SAFE approach to encourage natural enemies – see pages 185–186.

Slug damage to grain

Slug damage to lettuce

Monitoring

Use refuge traps. Traps consist of a cover, such as an empty sack, carpet square or a tile, with a non-toxic bait, such as chicken layers mash, to assess slug activity. Do not use slug pellets to bait traps.

Put slug traps out before cultivation, when soil is moist and temperatures range from 5–25°C. In each field, nine traps (13 in fields larger than 20 ha) should be set out in a 'W' pattern, concentrating on areas known to suffer damage. Leave the traps overnight and examine early the following morning.

Monitor crops regularly for slug damage. The critical control periods depend on the crop.

Garden slug

Thresholds

The following represent potential risk of damage when soil and weather conditions favour slug activity:

- Winter cereals: four slugs per trap
- Oilseed rape: one slug per trap in cereal stubble
- Vegetables: no thresholds established
- Other crops: one slug per trap

Keeled slug (*Milax budapestansi*)

Insecticide resistance

None known.

Slug infected with *Phasmarhabitis hermaphrodita*

Slug damage to sugar beet

Pests: Other

177 Soil pest complex

180 Minor and/or emerging pests

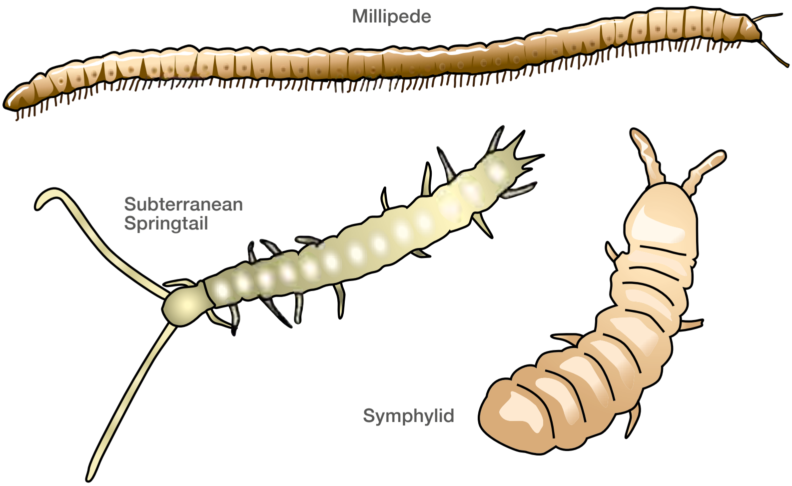
180 Globular springtails (*Sminthurus* spp. and *Bourletiella* spp.)

180 Two-spotted spider mites (*Tetranychus urticae*)

Soil pest complex

Crops affected

Alliums	Carrots	Cereals	Field beans	**Lettuce**
Oilseeds	Peas	**Potatoes**	**Sugar beet**	Vegetable brassicas



The soil pest complex includes millipedes, subterranean springtails and symphylids. While not related, these species are grouped because they can appear at the same time and cause similar types of damage by feeding on roots, causing seedlings to collapse and die. These creatures live underground and have variable numbers of legs. Being subterranean, they are generally white or pale in colour.

Importance

Pests in this complex can attack sugar beet from germination onwards, causing feeding damage to the roots and stem below the soil. They can slow seedling growth and kill seedlings, leading to bare crop patches in the spring.

Symphylids may also attack crops such as potatoes, tomatoes and lettuce.

Risk factors

- The risk is higher in cold, wet springs
- The complex is more common in fields with plenty of fresh organic matter or an open soil texture
- Plants are less susceptible to attack by millipedes once they are beyond the four true leaf stage

Life cycle, identification and symptoms

Millipedes

Millipedes (*Blaniulus* spp., *Brachydesmus* spp., *Polydesmus* spp. and others) occur in two types: snake millipedes and flat millipedes. All have a body with many segments. Each segment has two pairs of legs. They are approximately 1 mm in diameter and 10–20 mm long.

Adults breed in spring and summer, laying eggs in 'nests' in the soil. The young have three pairs of legs and add more segments, each with a pair of legs, until they mature after 2–3 years.

Springtails

Subterranean springtails (*Onychiurus armatus* and *Folsomia fimetaria*) are white with an elongated body (on average 1 mm in length).

Springtails have two breeding peaks per year: one in late spring and the second in the autumn/winter.

Symphylids

Symphylid (*Scutigerella immaculata*) adults are active, with a slender body that is 5–7 mm in length. They are white and shiny, with two long antennae and 12 pairs of legs.

Adults lay eggs throughout the year in batches of up to 20. Young symphylids have three pairs of legs and go through a series of moults, adding a pair of legs each time until they have 12 pairs in total. This process takes 3 months and symphylids can live for several years.

Some feeding damage is superficial, but some can be deeper, causing pits in the roots, especially before emergence. Grazing of the root stem and root hairs causes the seedling to collapse and die. Sites at which damage has occurred can be prone to secondary pathogenic fungi.

Management

Non-chemical control

Damage is more severe when seedling growth is slow. Measures to improve establishment can help plants grow away from damage.

Monitoring

Bare patches in the field may suggest damage by the soil pest complex. Millipedes and symphylids may be seen in soil samples with the naked eye, but magnification is needed to see springtails.

Thresholds

There are no thresholds. Yield loss is associated with loss of plants. Crops with very low populations may need to be re-drilled with insecticide-treated seed.

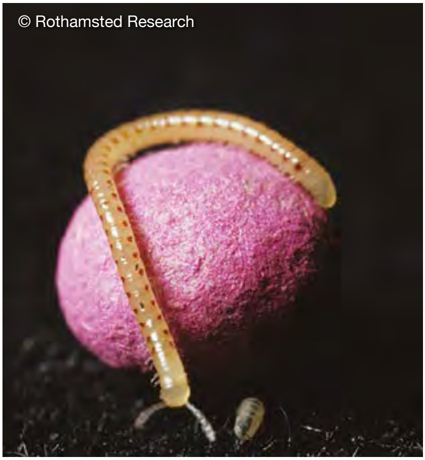
Insecticide resistance

None known.

Flat millipede

Springtail

Symphylid



Spotted snake millipede

Minor and/or emerging pests

Globular springtails (*Sminthurus* spp. and *Bourletiella* spp.)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

In contrast to the subterranean springtails of the soil pest complex (see page 178), these springtails live above ground. They have a globular body and are light green or purplish.

They feed on cell contents through puncture wounds on the cotyledons or true leaves, causing superficial damage. They are not a serious pest.

On the leaf, however, green-coloured springtails can easily be mistaken for green aphids. They are readily distinguished from aphids because they jump when disturbed.

Two-spotted spider mites (*Tetranychus urticae*)

Crops affected

Alliums	Carrots	Cereals	Field beans	Lettuce
Oilseeds	Peas	Potatoes	**Sugar beet**	Vegetable brassicas

Two-spotted spider mites are small, round, yellowish-brown in appearance and have two dark spots on the abdomen.

They invade crops from their overwintering hosts on parachutes of silken threads blown in the wind. As such, they generally appear first on headlands.

Symptoms are yellow spots on the leaf surface and a dark colouration underneath, often with webs visible. They are visible with the naked eye. Damaged leaves die and defoliation can occur in severe infestations.

Two-spotted spider mites are favoured by warm, dry weather. Control is usually by natural predators.

Spider mite

Early symptoms of spider mite damage

Severe symptoms of spider mite damageunder surface

Natural enemies

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185 How to utilise and enhance natural enemies: the 'SAFE' approach

187 Beetles (Coleoptera)

187 Ground beetles (Carabidae)

189 Rove beetles (Staphylinidae)

191 Soldier beetles (Cantharidae)

192 Ladybirds (Coccinellidae)

193 Bugs (*Hemiptera*)

193 Flower and pirate bugs (Anthocoridae)

194 Damsel bugs (Nabidae)

195 Assassin bugs (Reduviidae)

196 Centipedes (Chilopoda)

197 Flies (Diptera)

197 Robber flies (Asilidae)

198 Long-legged flies (Dolichopodidae)

199 Balloon and dagger flies (Empididae)

200 Dance flies (Hybotidae)

201 Dung flies (Scathophagidae)

202 Gall midges (Cecidomyiidae)

203 Hoverflies (Syrphidae)

204 Lacewings (Neuroptera)

204 Green lacewings (Chrysopidae)

204 Brown lacewings (Hemerobiidae)

205 Sawflies, wasps, ants and bees (Hymenoptera)
205 Bees, true wasps and ants (Apocrita-Aculeata)
207 Parasitic wasps/parasitoids (Apocrita-Parasitica)
211 Spiders and mites (Arachnida)
212 Money spiders (Linyphiidae)
212 Wolf spiders (Lycosidae)
212 Predatory mites (Phytoseiidae)

An introduction to natural enemies

This section describes the main invertebrate orders and families that contain the most important natural enemies of field crops.

Natural enemies (beneficial insects or 'beneficials') regulate crop pests to varying degrees. Effective regulation can help keep pest populations below economically damaging levels and avoid the need for chemical control. It is important to encourage specialist natural enemies, which attack a particular pest species, and generalist natural enemies. This diversity will provide the most robust regulation and encourage synergistic activity. For example, parasitic wasps may cause aphids to fall to the ground, where they are predated by ground-foraging species. Agricultural ecosystems are complex, but the table below provides a high-level summary of the potential interactions between pests and natural enemies.

Pest group	Natural enemy group						
	Beetles	Bugs	Flies	Lacewings	Parasitoids	Spiders and mites	Birds
Aphids	✓	✓	✓	✓	✓	✓	✓
Beetles					✓		✓
Beetle eggs and larvae	✓				✓		✓
Flies			✓			✓	✓
Fly eggs and larvae	✓		✓		✓		✓
Moths and butterflies							✓
Moths and butterfly eggs and larvae	✓				✓		✓
Slugs	✓				✓		✓
Mites	✓	✓	✓		✓	✓	
Thrips	✓	✓	✓	✓	✓	✓	

Encouraging natural enemies

A diverse landscape, with many hedgerows and flower-rich grassland, often provides natural enemies with adequate habitat. Elsewhere, especially in open, simple landscapes and where there are large fields, extra provision is needed. Appropriate management encourages populations of natural enemies. Specifically, integrated pest management (IPM) will help limit insecticide use.

Attributes of an effective natural enemy

Many organisms, such as invertebrate natural enemies, insect-pathogenic fungi, nematodes and other microorganisms, contribute to crop pest control. The most effective natural enemies share common characteristics:

- Their primary prey or hosts are pest species
- They use visual or chemical cues to locate prey/hosts
- They vary their reproductive capacity in response to prey abundance or adverse farming practices
- They are sufficiently mobile to penetrate the largest fields and reinvade after detrimental agricultural operations
- They maintain consistent densities and are able to survive adverse farming practices

Balloon and dagger fly with prey

Hoverfly (*Episyrphus balteatus*) adult

Marsh damsel bug (*Nabis limbatus*)

How to utilise and enhance natural enemies

The 'SAFE' approach

Natural enemies require appropriate resources to help keep pests in check.

S is for 'shelter'

Hedgerows, associated margins and other shrubby areas are protected from insecticides and intensive tillage. Such habitats enable beneficial insects to repopulate nearby crops. Strips of tussocky grasses and flower-rich grassland support high densities of some species. Natural enemies that only live for part of the year within a crop need other habitats in which to forage, breed or survive dormant periods. Provide shelter for natural enemies by:

- Managing hedges to create different structures with varied plant species
- Re-sowing any degraded hedge bases covered in noxious weeds (such as ragwort or thistles) with a flower-rich grass mix
- Protecting natural vegetation along hedge bases and fence lines from insecticide and herbicide drift
- Ploughing two furrows together to form a raised 'beetle bank' to create drier conditions favoured by insects and divide larger fields – sow with tussock-forming grasses

A is for 'alternative prey'

Pests often occur sporadically during the growing season, with shorter life cycles than natural enemies. Other food sources (alternative prey) within and outside fields are needed to maintain natural enemy populations. Food sources include:

- Other crops
- Uncropped areas, such as field margins, woodland and less intensively managed grassland
- Undersowing
- Weeds (uncompetitive)
- Minimum tillage
- Organic manures

Minimum tillage and application of organic manures are especially valuable for providing suitable conditions for detritus-feeding invertebrates that serve as alternative prey for predators.

F is for ‘flower-rich habitat’

Pollen and nectar are essential for some groups of natural enemies, especially parasitic wasps and hoverflies. They are important foods for many other natural enemies.

Woodlands, hedges, margins, crops and agri-environment habitats containing wild flowers, annual arable plants or flowering wild bird seed plants can supply pollen and nectar. These flower-rich areas also support alternative prey.

Flower-rich areas can be created using a mix of wild flowers and grasses or legumes. Mixes that provide both complex and simple flowers are the most beneficial because these support both short- and long-tongued insects.


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E is for ‘environment’

Insect natural enemies thrive in diverse vegetation that has not been treated with insecticides, such as field margins. All insecticides affect them to some degree, so it is important to minimise usage by adopting integrated pest management (IPM) practices. Other pesticides may adversely affect natural enemies, directly or indirectly; for example, removal of weedy habitats.

Correct management will help to create a habitat structure that provides natural enemies with cover and a suitable microclimate. Ensure habitats are:

- Spread across the farm – some natural enemies tend to remain close to margins
- Diverse – to encourage a variety of natural enemies


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Beetles Coleoptera

Beetles occur in all types of habitats and are among the most common insects found on farmland. Larvae usually live in the soil or in dead wood. Most adult beetles can fly, although they spend most of their time on vegetation or on the ground.

Many beneficial beetle species feed upon crop pests or contribute to pollination. However, some are pests (see the Pests: Beetles chapter). They are also important in the diet of farmland birds and some mammals.

Ground beetles (Carabidae) – 350 species

Identification

Eggs are ovoid and usually laid singly in or under the soil.

Larvae are elongated, with biting mouthparts. They have three pairs of legs, each of which has six segments with two claws at the end, and 10 abdominal segments. They can be confused with rove beetle larvae, but the heads of ground beetle larvae are flatter.

Adult ground beetles are of variable size (2–25 mm), are typically black or brown, often with metallic sheens; some are brightly coloured. They have biting mouthparts and are normally seen running on the ground. Most are flightless and usually nocturnal.

Life cycle

Within the ground beetles, there are varying life cycles. For example, some breed in the summer/autumn and overwinter as larvae, whereas others breed in the spring and overwinter as adults. Others flex breeding times according to the weather, while some have prolonged resting periods as adults. The life cycle can last from one to several years, with between two and five larval stages. Larvae are carnivorous, with the exception of *Harpalini* spp., which feed upon seeds. Adults usually overwinter outside of the crop, in field margins or woodland, whereas larvae are also found overwintering within fields at densities of up to 1 million per hectare.

Carabid larva

The generalist predator, *Poecilus cupreus*

A seed-feeding beetle, *Ophonus ardosciacus*

Benefits

Approximately 20–30 species are important for biocontrol; 5–10 are abundant on farmland. Beetles overwintering outside of the crop reinvade in the spring to help control pests, but most remain within 60 m of the edge. Consequently, coverage of large fields may not be achieved.

Ground beetles are generalist predators. They provide a background level of control for a variety of pests, such as aphids, fly eggs and larvae, moth/butterfly eggs and larvae, slugs and weed seeds. They also act synergistically with other natural enemies; for example, consuming pests dropping from the crop as they try to escape other predators or parasitoids.

Status

Although abundant on farmland, numbers have recently declined. Ground beetles are killed by most foliar-applied insecticides, as well as intensive soil tillage.

How to encourage

Techniques to encourage ground beetles include:

- Dividing large fields (>15 ha) with beetle banks to ensure more even coverage
- Having field margins with tussock-forming grasses
- Reducing the intensity of soil cultivations
- Using spray thresholds to reduce insecticide applications
- Allowing uncompetitive weeds to survive within the crop: low levels of weeds within crops also help to support ground beetles by providing cover and alternative food (insects and seeds)

The common, ground-dwelling generalist predator, *Pterostichus melanarius*, which overwinters as larvae in fields

The climbing predator, *Demetrias atricapillus*, which overwinters in field margins

The ground-dwelling predator, *Agonum muelleri*

Rove beetles (Staphylinidae) **– 1,000 species**

Identification

Eggs are white and round or pear-shaped.

Larvae are elongate, with three pairs of legs, each of which has five segments with one claw.

Adults are of variable size (1–25 mm) and elongate with flattened bodies. They typically have short wing cases that do not cover the abdomen, although this is not unique to this family. Some have distinctive colours, usually red and black, and are easy to recognise (see *Tachyporus hypnorum*), but most are black and indistinguishable. Most species can fly and climb well. They can be confused with earwigs.

Life cycle

The breeding period of rove beetles varies between species. Smaller species breed earliest, from February onwards and continue through to winter. For most species, adults emerge between May and August. Depending on the species, they overwinter as larvae or adults. Larval stages are typically short – a few days to weeks – but the adults are longer-lived.

Benefits

The diversity of species has resulted in a broad dietary range. It includes species that are scavengers, generalist and specialist predators, fungal feeders, leaf and flower feeders and parasitic.

Approximately 40–50 species are important for biocontrol, 5–10 are abundant on farmland.

In agricultural crops, the commonest species are omnivorous. The insect prey is frequently the eggs and larvae of flies, moths, butterflies, springtails and aphids. Rove beetles are consumed by other insects, amphibians, reptiles, birds and bats.

Status

Once numerous on farmland, numbers have declined sharply in recent decades, especially fungal-feeding species, such as the Tachyporinae. This is possibly associated with fungicide use.

Tachyporus hypnorum feeds on insects and fungi and overwinters at the base of tussocky grasses

Philonthus cognatus, one of the larger farmland rove beetles, overwinters in fields

Rove beetles are especially vulnerable to insecticide sprays applied in the spring and autumn. Ploughing may not directly reduce numbers, but rove beetle abundance and species diversity is higher with minimal tillage, owing to indirect effects (more surface litter, weeds, soil moisture, fungi and detritivores).

Aleochara lata, with the typical shape of this highly abundant family of insects

How to encourage

They occupy most habitats, including crops, grassland and woodland. Rove beetles overwinter outside the crop in sheltered places, such as under rocks and bark or in grassy tussocks, or as larvae in the soil at densities of up to 500,000 per hectare.

The same methods used to encourage ground beetles will also favour rove beetles, especially reduction of all pesticide inputs because they are considered to be more sensitive.

For high value nursery crops, *Atheta coriaria* can be reared and released for the control of sciarid and shore flies – and potentially western flower thrips.

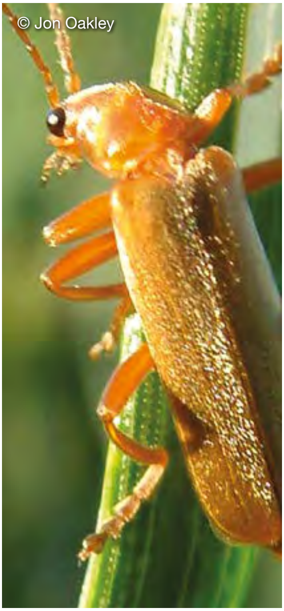
Soldier beetles (Cantharidae) – 41 species

Identification

Larvae are dark brown or grey, sometimes with a velvety appearance, highly segmented; almost worm-like.

Adults are narrow, elongated beetles (2–15 mm long), with soft bodies. Their name arose from the similarity of the red-coloured species to military uniforms. The wing cases are long, thin and covered with short dense hair, which gives them a dull, matt appearance. The adults can be brightly coloured, either yellow or red (as in red soldier beetles), or are dark brown or black (known as sailor beetles); sometimes with yellow-tipped wing cases.

Adults are good fliers and larvae are capable of moving from margins into fields.



Rhagonycha fulva is typically seen mating on cow parsley and hogweed flowers

Life cycle

One or two generations are produced each year. Adults feed predominantly on nectar, pollen and honeydew, but can be carnivorous, feeding on live and dead soft-bodied insects, such as caterpillars, spider mites and aphids. At mating time, they are often seen on the flower heads of umbellifers.

The adults and soil-active larvae of *Cantharis livida* are predatory

Benefits

Larvae feed on vegetation but are rarely pests and, when larger, prey on fly larvae, caterpillars and earthworms.

Adults are carnivorous and feed on other flower visitors.

Five species are important for biocontrol; three are abundant on farmland.

Status

Abundant in meadows and flower-rich field margins, they are frequently observed visiting umbellifer flowers, such as cow parsley.

How to encourage

Larvae prefer dense vegetation; cover crops in winter may encourage larvae into arable fields from field boundaries. Flower-rich habitats, especially those containing umbellifers, will attract adults.

Ladybirds (Coccinellidae) – 53 species

Identification

Eggs are easily recognisable: usually elongate, oval-shaped and laid end-up in batches. Their colour varies between species, ranging from light yellow to dark orange.

Larvae are brightly coloured and have a distinctive appearance. They are commonly seen feeding on aphids in crops.

Adults (1–10 mm long) are, typically, brightly coloured (yellow, orange or scarlet), usually with patterned (spots, bands or stripes) wing covers, domed bodies and short, club-shaped antennae.

The larva of the non-native, invasive Harlequin ladybird

Larva of the seven-spot ladybird

Adult seven-spot ladybird (left) and adult cream-spot ladybird preparing to fly (right)

Life cycle

The life cycle usually lasts about 1 year; occasionally there are two generations per year. Eggs are laid in spring to early summer, close to their larval prey.

Pupation occurs in mid-summer and adults emerge during mid-to-late summer. With sufficient food and warmth, larval development is faster and two generations per year are possible. They overwinter as adults in sheltered places, such as in leaf litter, grass tussocks, bark crevices and buildings. They emerge in spring and seek out mates.

Benefits

Their most common food is aphids and scale insects, although a few species feed on fungi. The 24-spot species feeds on plants. Five species are considered important for the control of aphids on cereals, potatoes and sugar beet. Ladybirds are good flyers; however, adult dispersal is random and it is only when they settle on a plant that more systematic searching occurs, aided by olfactory cues.

Status

Threatened by the invasion of the non-native Harlequin ladybird, which competes for food and consumes the larvae of native ladybirds.

How to encourage

Adults are attracted to simple, open flowers; for example, wild carrot, angelica and yarrow, where they feed on nectar and pollen. The use of broad-spectrum insecticide sprays should be avoided.

Bugs include true bugs (Heteroptera), aphids and whiteflies (Sternorrhyncha) and hoppers (Auchenorrhyncha). However, only Heteropteran species are natural enemies and their contribution to pest control is unknown.

Of the carnivorous families, only Anthocoridae and Nabidae, occasionally Reduviidae, occur on farmland.

Flower and pirate bugs (Anthocoridae) – 33 species

Identification

Flower and pirate bugs are difficult to identify to species level. They are small (2–6 mm) and generally flattened, oval or long, with a head that has a parallel-sided snout. The end antennal segment is coloured.

Life cycle

There are one to three generations per year and they overwinter as adults. Eggs are laid singly, just beneath the surface of their prey's host plant. Each female typically lays 50 or more eggs and there are five nymphal stages. Adulthood is reached in about 50 days.

Benefits

Each predatory nymph consumes up to 240 aphids. Most adults are highly mobile and seek out their prey, making them effective predators. They are most commonly found on trees and shrubs, where the larvae and adults feed on eggs and the immature and adult stages of immobile insects, such as thrips, aphids, mites and whiteflies. Some are specialised and feed on leaf-mining caterpillars.

Status

Unknown.

How to encourage

They may benefit from floristically diverse field margins and non-crop habitats that contain alternative prey.

Adult flower bug (*Anthocoris nemoralis*)

Flower bug nymph

Adult flower bug (*Orius insidiosus*) feeding on thrips

Damsel bugs (Nabidae) – 12 species

Identification

All species are brown, slender with long legs and a four-segmented beak. They are approximately 6–12 mm long.

Life cycle

Damsel bugs have one generation per year, although they are capable of producing hundreds of eggs laid in rows of 5–10 on plant stems. They have either four or five nymphal stages, overwintering as eggs or adults.

Benefits

The adults are frequently flightless, but they are still mobile, aggressive predators that feed on a variety of insects. They are found on plants on the ground and in margins, shrubs and trees.

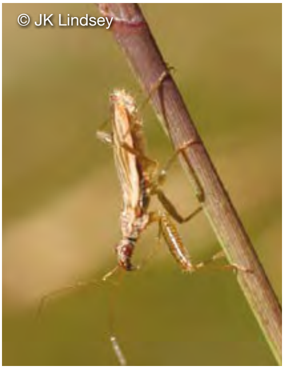
Status

Unknown.

How to encourage

They may benefit from floristically diverse field margins and non-crop habitats that contain alternative prey.

Marsh damsel bug (*Nabis limbatus*)



Damsel bug (*Nabis rugosus*)

The ground-dwelling predator (*Agonum muelleri*)

Assassin bugs (Reduviidae) – 8 species

Identification

Assassin bugs can be large (4.5–18.0 mm) and have a short, curved rostrum.

Life cycle

They have one to two generations per year, although they sometimes take more than 1 year to reach maturity. Assassin bugs overwinter as eggs, larvae or adults.

Benefits

Larvae and adults are predators of immature and adult stages of flies and beetles, as well as caterpillars. They inject lethal saliva for extra-oral digestion. They may also bite humans.

Status

Unknown.

How to encourage

They may benefit from floristically diverse field margins and non-crop habitats that contain alternative prey.

Thread-legged bug (*Empicoris vagabundus*)

Centipedes Chilopoda

Identification

Centipedes are not insects but belong to the myriapods, meaning ‘many legs’.

The 57 species of centipede have a variable odd number of flattened segments, each bearing a pair of legs. The first pair of legs is modified to form a pair of pincers that inject venom into their prey. They are typically drab brown and 30–60 mm long.

In contrast, millipedes are vegetarians and have two pairs of legs on each segment.

Life cycle

Eggs are laid singly or in batches; some species care for their eggs. The larvae develop into adults through a series of moults. Generation time is usually 1 year, but adults may live for several years.

Benefits

Most are predatory, living in the soil, dead wood or leaf litter and predating any soft-bodied insects and earthworms.

Status

Unknown.

How to encourage

Unknown.

Variegated woodland centipede

Western yellow centipede

Flies Diptera

The Diptera is a very diverse order, with just over 7,000 species. Flies occur everywhere and are commonly known on farmland, where they may be pests (see the Pests: Flies and sawflies chapter), pollinators or natural enemies.

Although numerous predatory species are common on farmland, relatively little is known about their ecology and contribution to pest control, except for the hoverflies (page 203). Likewise, many species may pollinate flowers, but their overall importance for pollination is poorly understood. They also contribute to nutrient recycling of dung and vegetation.

Robber fly (*Dioctria baumhaueri*) with prey

Robber flies (Asilidae) – 29 species

Identification

Adults are of variable size, 3–50 mm long (typically 9–15 mm long) and vary in shape, from long and slender to short and stout. Likewise, colourings are variable, sometimes with yellow or orange markings on the body, similar to the markings of wasps and bees (warning signs). They are relatively rare on farmland.

Life cycle

The number of generations per year varies from one to several, depending on the species.

Robber fly (*Dioctria rufipes*)

Benefits

Larvae predate the larvae of other insects, either in the soil or in decaying wood. Adults are agile flyers, capable of catching other insects on the wing, and spiders. They are found in most types of uncropped land on farmland. Two species are considered important for biocontrol.

Status

Unknown.

How to encourage

Robber flies favour open, sunny habitats, comprising grassland and shrubs or hedgerows.

Long-legged flies (Dolichopodidae) – 287 species

Identification

Adults are small, 1–9 mm long, with long slender legs. They tend to have metallic green bodies, although they can be yellow, brown or black. The wings are opaque or with dark areas towards the tips.

Life cycle

Larvae develop in the soil, on dead organic matter or in crevices on trees and are predatory or are leaf-miners. The number of generations per year is unknown. The adults are strong flyers.

Benefits

Larvae may predate small, soil-inhabiting insect pests. Adults are very common in field margins and crops, predating small invertebrates, including pest aphids, midges, thrips and other fly larvae or adults, or only feed on floral resources. Six species are important for biocontrol.

Status

Unknown

How to encourage

Techniques to encourage long-legged flies include:

- Providing field margins with diverse flowering shrubs and herbaceous plants
- Avoiding cutting in the summer
- Preventing pesticide drift into margins

Long-legged fly (*Dolichopus* sp.)

Long-legged fly (*Poecilobothrus nobilitatus*)

Balloon and dagger flies (Empididae) – 208 species

Identification

Balloon and dagger flies are distinguished by a small, round head, large eyes and a hump-backed thorax. Shapes vary from slender to robust and they vary in size from tiny to large (1–12 mm).

Life cycle

The life cycle of these flies is poorly understood. There is probably one generation per year.

Benefits

Larvae predate other insects in the soil or dead wood, or are aquatic.

Adults are typically predatory, with strong, piercing mouthparts. They predate aphids, psyllids, whiteflies, coccids, midges, thrips and mites.

Adults of some species feed on pollen and nectar.

Six species are considered important for biocontrol.

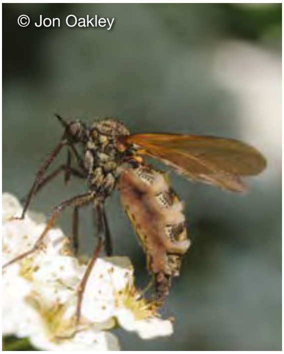
Status

Balloon and dagger flies are very abundant in field boundaries and some crops.

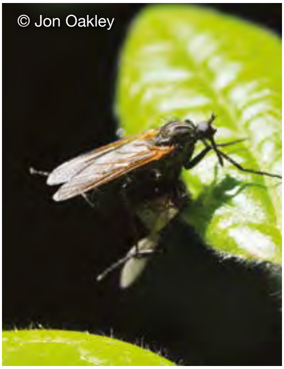
How to encourage

Techniques to encourage balloon and dagger flies include:

- Providing field margins with a variety of flowering shrubs and herbaceous plants
- Avoiding cutting margins in summer
- Preventing pesticide drift into margins



Balloon and dagger fly (*Empis entomophthora*)



Balloon and dagger fly (*Empis* spp.)

Balloon and dagger fly with prey

Dance flies (Hybotidae) – 175 species

Identification

Dance flies are small (1–6 mm) and their shapes vary from slender to robustly built. They have a humped thorax and are very similar to, but smaller than, the Empididae.

Life cycle

A dance fly completes one or two generations per year.

Benefits

Adults mostly predate small insects, such as aphids and midges, in cereals and oilseed rape. The larvae are predatory and live in the soil, dead wood or organic detritus. Four species are considered important for biocontrol.

Status

Dance flies are often highly abundant along field boundaries and within fields.

How to encourage

Techniques to encourage dance flies include:

- Providing field margins with a variety of flowering shrubs and herbaceous plants
- Avoiding cutting margins in summer
- Preventing pesticide drift into margins

Dance fly (*Platypalpus* spp.) with orange wheat blossom midge

Dung flies (Scathophagidae) – 54 species

Identification

Colour varies from dull yellow-brown to black and/or yellow. The shape varies from slender to robust and the size from small to large (3–12 mm). The flies have bristly bodies and legs.

Life cycle

Dung flies have diverse life cycles, depending on larval feeding habitats. The number of generations per year is unknown.

Benefits

Larvae feed on plant leaves and flowers, detritus, dung or eggs of aquatic insects. Adults are predatory on soft-bodied insects, often associated with dung. Six species are considered important for biocontrol.

Status

Unknown

How to encourage

Dung flies favour mixed farming systems where dung is available.

Adult dung fly

Adult dung fly

Gall midges (Cecidomyiidae) – 620 species

Identification

Members of the midge family can be distinguished by their broad, round, often fringed wings. They are minute to tiny (0.5–3 mm) and hard to identify.

Life cycle

Two to three generations per year are typical. Adults only feed on nectar or honeydew. Overwintering occurs in the soil.

Benefits

The pest midge species and those that form galls are more commonly known; however, the larvae of at least five species feed on aphids, while others predate mites.

Of the aphidophagous species, each female can lay 50–150 eggs close to the aphid colony; each larva can consume up to 80 aphids.

Adults of some species are also predatory.

Status

Unknown.

How to encourage

Field margins with diverse flowering shrubs and herbaceous plants provide a source of nectar for adults.

A few species are reared and released for biocontrol programmes in protected crops, strawberries and ornamentals; for example, *Aphidoletes aphidimyza* for aphid control and *Feltiella acarisuga* for spider mite control.

Gall midge larva feeding on peach–potato aphids

Gall midge larvae feeding on aphids

Hoverflies (Syrphidae) – 274 species

Identification

Eggs are ovoid and laid singly or in groups, depending on the species.

Predatory larvae are coloured, unlike other fly larvae, which are white or dirty yellow.

Pupae can sometimes be found attached to leaves.

A variety of colours is found in adults, although species with predatory larvae are black with white or yellow spots or bands, similar to bees and wasps.

Shapes vary from slender to stout and size varies from small to very large (3.5–35.0 mm). They are characterised by their ability to hover.

Hoverfly larva and pea aphid

Hoverfly (*Episyrphus balteatus*) pupa

Hoverfly (*Episyrphus balteatus*) adult

Life cycle

This is a highly diverse group with wide-ranging life histories. Typically, generation time is one or several per year. Adults are highly mobile, capable of migrating hundreds of miles.

Benefits

They are highly effective natural enemies because of their mobility and short generation time. Aphids are the predominant prey of species with predatory larvae. Each can consume up to 1,200 aphids. Larvae are largely nocturnal and are rarely seen on plants. Larvae of other species feed upon fungi, plant parts or detritus, or are aquatic. Adults feed on the pollen and nectar of simple open flowers, usually white or yellow, such as umbellifers and daisies, and assist with pollination. Six species are important for biocontrol, two of which are very abundant.

Status

Numbers are declining, especially those species with just one generation per year.

How to encourage

Attract adults by planting appropriate flower-rich habitats, but they will only remain if suitable densities of aphid prey are available. Hoverflies feed on the flowers of annual arable plants (such as cornflower, chickweed, knotweeds and shepherd's purse) and hedgerow plants (wild carrot, cow parsley, hogweed and white campion). In addition, flower strips can be established specifically for hoverflies in and around fields containing coriander, buckwheat, phacelia or alyssum.

Lacewings Neuroptera

Identification

Eggs are laid in groups, attached to vegetation. Larvae have distinct, arrow-shaped, brown bodies with large pincers. They sometimes attach remains of their prey to their backs as camouflage. Adults have large, translucent wings that are held roof-like above their bodies. Their wings are longer than their bodies.

Lacewing larva

Life cycle

Lacewings can produce several generations per year. Eggs develop in 6–30 days. There are three predatory larval stages. Larvae may also feed on extrafloral nectaries. Pupation occurs in a cocoon on plants and overwintering can occur either at this stage or as adults.

Benefits

Larvae and adults usually prey on soft-bodied insects, especially aphids, although adults may also consume nectar, yeasts, pollen and honeydew.

Lacewings can respond to chemical cues associated with aphids. The number consumed by each larva varies, but can exceed 1,500. Their effectiveness in controlling aphid outbreaks is, however, uncertain.

Status

Unknown.

How to encourage

Adults may be attracted by flower-rich areas and plants that support aphids. They are attracted to strips of buckwheat. There are two important families for pest control: the green and the brown lacewings.

Green lacewings (Chrysopidae) – 20 species

Identification

- Green bodies and golden eyes
- 20–25 mm long
- Females lay 150–600 eggs each

Chrysopa perla

Brown lacewings (Hemerobiidae) – 31 species

Identification

- Brown or grey bodies
- 6–25 mm long
- Less noticeable than green lacewings
- Females lay 600–1,500 eggs each

Hemerobius nitidulus

Sawflies, wasps, ants and bees Hymenoptera

This order of insects is the largest, comprising 57 families. It encompasses insects with very different life forms and biology.

The order is divided into three suborders:

1. Apocrita-Aculeata

- Stinging insects
- Slender-waisted
- Includes social insects, such as bees, wasps and ants
- Also includes some solitary predatory wasp species

2. Apocrita-Parasitica

- Parasitic wasps
- Slender-waisted
- In many situations, the most important group of natural enemies

3. Symphyta

- Sawflies and woodwasps, some of which are pests
- Plant-feeding
- No obvious waist

Adult hymenoptera require proteins for egg development and most feed on honeydew, nectar or other plant secretions.

Adults of some species are carnivorous (for example, ants, vespid wasps and some sawflies).

The feeding habitats of social insects are complex and may involve the collection and storage of plant and animal food or culturing of fungi and other insects.

Hornet

Parasitoid wasp (*Stenomalus micans*)

White-tipped sawfly (*Taxonus terminalis*)

Bees, true wasps and ants (Apocrita/Aculeata)

There are parasitic species within this suborder, but these lay eggs near the host and their larvae attack hosts from the outside.

Solitary wasps (Crabronidae) – 118 species

Identification

- Adult females take other insects, including other natural enemies, to feed their young in nests
- Their contribution to biocontrol is unknown

Crabronid wasp (*Nysson spinosus*)

Bethylid wasps (Bethylidae) – 22 species

Identification

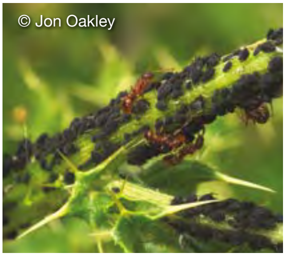
- Ectoparasites of beetle (including stored product pests), moth and butterfly larvae

Bethylid wasp

Ants *(Formicidae)* – 60 species

Identification

- Some species are predatory, while others ‘farm’ aphids
- Confined to uncultivated land



Black bean aphids attended by ants (*Myrmica* spp.)

True wasps (Vespoidae) – 7 species

Identification

- Some species are predatory, while others ‘farm’ aphids
- Confined to uncultivated land

Common wasp (*Vespa vulgaris*)

Parasitic wasps/parasitoids Apocrita/Parasitica

Identification

There are thousands of species of parasitoids. Most species are wasps, but there are also families of parasitoid flies and beetles. Adult parasitoid wasps are usually small and hard to identify, requiring magnification.

In some cases, it is possible to identify when the host has been parasitised; for example, mummified aphid nymphs and adults, or by changes in egg colouration. This can provide an insight into the proportion of parasitised pests and whether or not chemical treatments are needed.

Life cycle

There is a huge number of parasitoid species. These coexist with hosts in diverse ways.

The larvae of parasitic Hymenoptera are usually endoparasites (the egg is laid on or inside the host and the larvae consume it, usually killing it); such insects are called parasitoids. There are also examples of ectoparasites, which feed outside of the host's body, and some that parasitise plants (for example, gall wasps). In a few cases, there are species with plant-feeding larvae (for example, Agaonidae and Cynipinae) or with predatory larvae.

Adults feed on nectar, pollen and honeydew, although females of at least 17 families also feed on their hosts, consuming body fluids. The amount and quality of adult food can, in some cases, extend the adult's lifespan and increase fecundity.

Adult parasitoids often emerge in areas devoid of their hosts. They use chemical and physical parameters to locate their host's habitat and, eventually, the hosts. This is followed by a process to determine host suitability and acceptance.

Parasitoids overwinter within their host, either coinciding their development with that of the host, or altering the host's development for their own purpose.

Mummified potato aphid

Parasitoid wasp (*Macroglens penetrans*)

Parasitoid laying eggs in an aphid

Benefits

Almost every life stage of each insect species is parasitised by one or more wasps; even parasitic wasps can be parasitised by hyperparasitoids. Typically, each parasitoid species attacks a specific host species or closely related group of species. They have developed venoms to immobilise their host and an ovipositor that can place eggs precisely within or on the host.

Parasitoids are important in the control of most pests, with those from the Ichneumonidae and Braconidae (superfamily Ichneumonoidea) being the most important, comprising over 3,000 species. The other common superfamily in agricultural crops is the Chalcidoidea, most of which are parasitoids, often of eggs.

Parasitoids can control the sex of their offspring and, consequently, the number of fertile females and infertile males. Some species can also produce eggs that continue to divide after laying, producing more than one larva. These attributes give them the ability to respond to their environment by controlling their reproductive output.

Status

Cereal pests	Number of important parasitic species*
Cereal aphids	8
Orange wheat blossom midge	4 (3)
Yellow wheat blossom midge	3
Frit fly	91 (2)
Gout fly	2
Yellow cereal fly	0
Wheat bulb fly	2
Cereal leaf beetle	3
Cereal ground beetle	Unknown
Wireworm	Unknown
Cereal stem sawfly	2
Leatherjackets	2
Slugs	10–20

Oilseed rape pests	Number of important parasitic species*
Cabbage aphid	3
Peach–potato aphid	2
Brassica pod midge	>20 (2)
Cabbage root fly	2
Cabbage flea beetle	4
Cabbage stem flea beetle	8 (1)
Rape winter stem weevil	4 (2)
Seed weevil	>20 (3)
Cabbage stem weevil	6 (1)
Rape stem weevil	3 (1)
Pollen beetle	9 (3)
Turnip sawfly	2
Slugs	10–20

*(abundant species in brackets)

How to encourage

In some cases, parasitoids provide sufficient control to prevent pest outbreaks. However, it may be necessary to adopt specific crop management practices to aid them.

Parasitoids are vulnerable to the direct and indirect effects of pesticides. This is because of their small size, dependence on pests as hosts and preference for floral resources that are usually located on the top of the canopy. Only spray when thresholds are exceeded and avoid drift into uncropped areas.

Parasitoids may benefit from supplies of nectar provided by simple open flowers, such as those on buckwheat and umbellifers. Alternative host species may be needed outside the crop growing season.

Parasitoids are weak flyers. To improve parasitism rates for those species that overwinter in the soil (for example, parasitoids of pollen beetle), adopt minimum tillage and plant crops near to the previous year's location.

Parasitoid wasps on cow parsley

Spiders and mites *Arachnida*

Identification

Spiders are arachnids, not insects. They have four pairs of legs, no wings and no antennae. They have only two body regions. Harvestmen are most likely to be confused with spiders. In harvestmen, the two parts of the body are broadly joined, whereas in spiders, the body is clearly divided into two parts that are joined by a narrow stalk. Harvestmen have only two eyes, whereas spiders have six to eight eyes.

Spiders and harvestmen are generalist predators and, consequently, may capture other pest natural enemies. They provide background levels of control, but the more mobile species only settle in locations with sufficient prey, so exhibit some response to prey densities.

Life cycle

The generation time varies hugely between species, from short-lived species with multiple generations per year to those that produce one generation per year and live for several years. Eggs are laid in clutches inside a silk sac. They emerge as spiderlings, which, in some species, are cared for by the female. Spiderlings pass through several moults before reaching adulthood. Some spiders are capable of dispersing over large distances by spinning a long thread on which they are carried by air currents; this is known as ballooning.

Benefits

Spiders are carnivorous and are unique in having a spinner near the hind end of the abdomen, which produces silk. Some spiders spin webs that are used as snares.

Others do not spin webs, but instead lie in wait for their prey or actively hunt. Web-spinning spiders are more effective predators because their webs can continue to catch prey after they have been abandoned. Spiders and harvestmen can be an important component of bird diets.

Status

Unknown.

How to encourage

For web-spinning species, vegetation, or a soil surface with a diverse architecture, provides more opportunities to build webs. Leaving trash on a cloddy surface helps retain spiders within fields in the autumn, while the presence of arable weeds provides a suitable structure in the spring and summer.

Wolf spiders occur predominantly along field margins and penetrate less than 60 m into fields. Splitting fields using beetle banks or similar vegetative strips can help improve coverage within fields.

Spiders are highly vulnerable to pyrethroid insecticides.

Money spiders (Linyphiidae) **– over 270 species**

- Largest European family
- Highly abundant, especially cereal crops
- Small grey or black-bodied spiders, 1.2–7.2 mm long
- Hunting or web building
- Drift through air on strands of silk

Wolf spiders (Lycosidae) **– 36 species**

- Hunting spiders, mostly at ground level but occasionally on low vegetation
- Mostly brownish, but attractively marked and clothed in dense hairs, 3.5–18.0 mm long
- Most abundant in field headlands
- Good runners and can jump
- Females conspicuous from May/June onwards, with brown or greenish-blue egg sacs

Predatory mites (Phytoseiidae) **– 34 species**

- Highly effective predators of spider mites owing to their voracity (20 spider mites per day), short generation time (1 week) and high fecundity (40–60 eggs per female)
- Some species are reared and released for biological control
- May also feed on other small insects, honeydew and pollen the latter boosting their reproductive capability
- More susceptible to insecticides than their spider mite prey

A money spider (*Erigone* spp.)

A money spider (*Linyphiid* spp.)

Wolf spider (*Pardosa* sp.)

Adult predatory mite (*Phytoseiulus persimilis*)

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